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ABNORMALLY WIDE RESPIRATORY MOVEMENT OF LOWER LUNG STRUCTURES

ROENTGEN EVIDENCE OF OBSTRUCTIVE EMPHYSEMA*

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THE physical phenomena of obstructive emphysema were first demonstrated on an experimental lung preparation in MacCallum's[5] laboratory by Thornton and Pratt[10] in 1908. They placed a dog's trachea and lungs in a bottle, with the trachea open to the air and the neck of the bottle sealed off. At the bottom of the bottle was a rubber diaphragm with which changes of pressure within the bottle could be produced simulating respiration. Partial constriction of a bronchus resulted in emphysema of that lobe after a few respirations.

Iglauer[1] in 1911 described a case of foreign body in a child's bronchus which caused overdistention of the lung. He mentioned the inspiratory expansion and expiratory contraction of the bronchial wall as an explanation for the obstructive emphysema produced by a foreign body which incompletely fills the lumen. Jacobson[3] (1913) described a case of bronchostenosis with increased radiability on the involved side which he attributed to difficulty in expiration leading to transitory emphysema. Ziegler[16] (1913) described a similar appearance with displacement of the mediastinum to the opposite side with expiration in a case of aneurysm of the aorta, which he attributed to a valve effect in the bronchus narrowed by pressure.

The most extensive studies of obstructive emphysema were those of Manges[9] to whom American roentgenology is greatly indebted.

Van Allen and his coworkers[4,11,12,13,14] produced obstructive emphysema experimentally in dogs by mechanical means. They found that if the first branch bronchus was left unobstructed neither atelectasis nor obstructive emphysema of the rest of the lobe could be produced. The unobstructed lobule through the first branch bronchus served as a pathway through which air could enter and leave the obstructed lobules. This is called by these workers "collateral respiration." A study of pressure changes in the obstructed bronchus by Van Allen, Lindskog and Richter[13,14] showed that the resistance offered to the interlobular transfer of air *in vivo* is very small, approximately 1 cm. of water. Collateral respiration is prevented by complete septa between the lobules and by inflammatory consolidation of the tissues at

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the border between the free and the obstructed portions of the lobe.

Obstructive emphysema, therefore, is a lobar phenomenon unless something is present to interfere with collateral respiration. How frequently this occurs in clinical conditions is a matter of conjecture at the present time.

CAUSES OF OBSTRUCTIVE EMPHYSEMA

The commonest cause of obstructive emphysema is probably foreign body in the bronchus. As suggested by the experimental work of Thornton and Pratt,[10] any disease process which narrows the bronchial lumen may result in obstructive emphysema. It has been described in the early stages of bronchial carcinoma. I have seen it in tuberculous ulcer of the bronchus, in pressure of an aneurysm on a bronchus (with atelectasis of another lobe), and in one instance apparently caused by mucous plugs and associated with complete but transitory atelectasis of another lobe. Wessler and Jaches[15] observed atelectasis of the right upper lobe with obstructive emphysema of the right lower lobe due to pressure of tuberculous mediastinal lymphadenitis in a three year old child.

NORMAL RESPIRATION

Normal respiratory movements of the lung are complex and an attempt to review them cannot be made here. Certain phenomena, however, must be mentioned.

In the normal chest on inspiration the diaphragm descends and the diameter of the thorax increases in all directions. As the lung expands, the hila descend and the trachea and bronchi elongate. Macklin,[6,7,8] who has made extensive studies of bronchial movement, states: "The interbronchial spaces show widening with inspiration without material alteration of the direction of the bronchi." On expiration the trachea and bronchi shorten, the hilum rises and, as the diaphragm rises, the bronchial shadows in the lower part of the lung approach each other. These respiratory changes in the normal lung markings are familiar to all experienced roentgenoscopists.

ROENTGEN SIGNS OF OBSTRUCTIVE EMPHYSEMA

Manges[9] summarized the roentgen signs of obstructive emphysema as follows:

1. Increased transparency of the affected lung.
2. Depression and limitation of movement of the diaphragm on the affected side.
3. Displacement of the heart and mediastinal structures away from the affected side.
4. Increased excursion of the diaphragm on the unaffected side due to compensatory emphysema.

As a corollary to 3, Jackson and Jackson[2] mention the to and fro movement of the heart with respiration (away from the affected side with expiration and back toward the normal position with inspiration).

It is quite obvious that the roentgen evidence of obstructive emphysema depends upon whether or not the involved lung or lobe occupies more space than it should at the particular phase of respiration at which the film was taken. At full inspiration there may be no evidence of overdistention, but at the end of expiration the effects of failure of deflation of a lobe or a lung may be obvious. Numerous writers have emphasized the importance of taking films on forced expiration as well as on inspiration, and of roentgenoscopic examination.

OBSTRUCTIVE ENPHYSEMA WITHOUT OVERDISTENTION

In some instances of inferior or middle lobe obstruction the emphysema may be relatively slight; the obstructed lobe may contain approximately the quantity of air it does at the end of a quiet inspiration. Even on forced expiration, although slightly increased radiability may be present in comparison with the rest of the lung, no limitation or flattening of the diaphragm and no displacement of the mediastinal structures may occur because the relatively

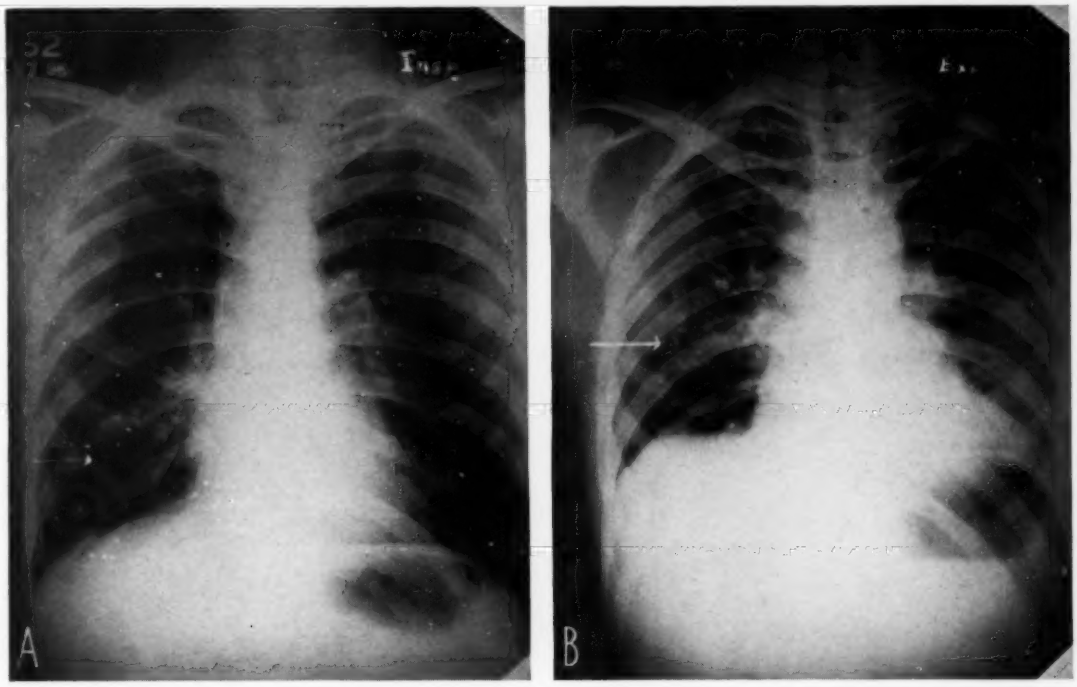

Fig. 1. Case 1. Tuberculous ulcer of the bronchus with obstructive emphysema of the right lower lobe. *A*, inspiration; *B*, expiration (November 27, 1935). The wide respiratory movement of the lung markings in the right lower lobe, so easily seen at roentgenoscopy, can be detected on the films taken at inspiration and expiration by noting the relative positions of the calcium shadows with regard to the diaphragm. The arrow points to the same shadow on the two films. It is farther from the diaphragm at expiration than at inspiration. This is probably due to the fact that the diaphragm moves backward a little as it ascends, thereby producing a greater excursion in the posterior part of the right lower lobe. The increased radiability of the right as compared with the left lower lobe on expiration can be clearly seen. On expiration the right margin of the heart shadow is slightly flattened (see Fig. 2).

increased space occupied by the incompletely deflated lobe may be compensated for by compression of the other normally deflatable lobe or lobes. Two recent cases in which this situation existed had been previously examined elsewhere without recognition of obstructive emphysema. In both instances, however, at roentgenoscopic examination during quiet respiration attention was instantly attracted to abnormal displacement of shadows in the lower part of the right lung parallel with and approximately equal to the diaphragmatic excursion. The purpose of this communication is to report these 2 cases and to call attention to this sigm of obstructive emphysema which apparently has not been mentioned in any of the literature on this subject which I have been able to consult.

REPORT OF CASES

Case 1. Male, aged twenty-eight, intern. About six weeks before admission, he noticed a clicking sound beneath the sternum on deep inspiration which would disappear for half an hour following a cough. About four weeks before admission he noticed a rattling sensation with a wheezing sound low in his chest, most marked on deep inspiration. Twelve years previously while in college he had a bad cough with fatigue and shortness of breath on walking four blocks. There was no loss of weight or night sweats. These symptoms disappeared without treatment. Four years before admission while interning in a tuberculosis sanatorium a routine film of his chest was made which was reported as showing healed, moderately advanced pulmonary tuberculosis.

The above-described symptoms caused him to fear that he had developed a carcinoma of the

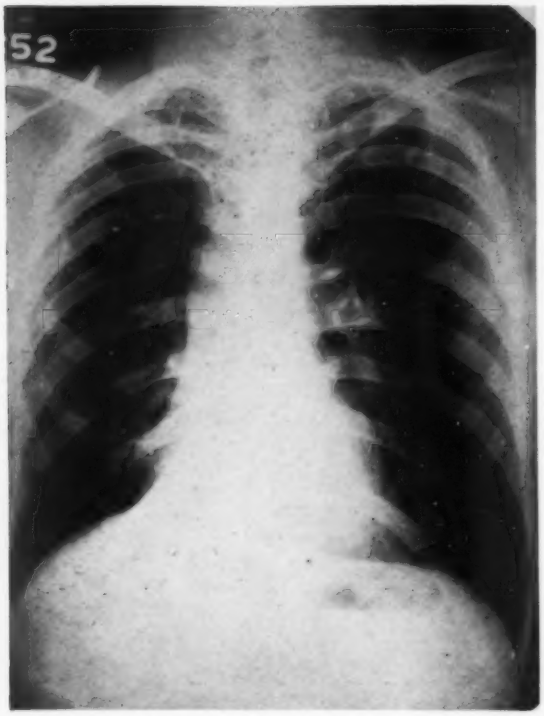

FIG. 2. Case 1. Tuberculous ulcer of the bronchus with atelectasis of the right lower lobe. A few days after the films of Figure 1 were taken, the wheezing, clicking sounds on respiration ceased. The film (December 9, 1935) shows an oblique shadow behind the right margin of the heart apparently representing the completely atelectatic right lower lobe. Comparison with Figure 1 *A* will show that many of the calcium shadows in the lower part of the right lung field have disappeared (see Fig. 3).

bronchus. A roentgenoscopic and a roentgenographic examination of the chest made elsewhere showed numerous calcium shadows in both lungs suggesting healed tuberculous lesions. After admission another roentgenoscopic examination disclosed a striking up-and-down movement of the calcium shadows in the lower part of the right lung, parallel with and approximately equal to the excursion of the right diaphragm. These shadows did not approach each other as the diaphragm rose on expiration and the right lower lobe did not appear to deflate. Displacement of the heart did not seem to take place and there was no limitation or flattening of the diaphragm. A diagnosis of obstructive emphysema of the right lower lobe was made.

He had no fever. The one specimen of sputum obtained showed acid-fast organisms.

Films on expiration and inspiration, November 27, 1935 (Fig. 1 *A* and *B*), showed no evidence of pulmonary tuberculosis except the old healed calcified lesions.

A few days later the noises in the lower part of the chest suddenly ceased. Roentgen examination December 9, 1935 (Fig. 2), showed a dense shadow extending downward and outward from the right margin of the heart to the dome of the diaphragm. Most of the calcium shadows had disappeared. Atelectasis of the right lower lobe had apparently taken place.

Bronchoscopy was done December 12, 1935. A small amount of exudate was present in the right middle lobe bronchus. A large amount of exudate was coming from the right lower lobe bronchus. When this was cleared away, a mass of pinkish granulation tissue was seen protruding from the wall of the right lower lobe bron-

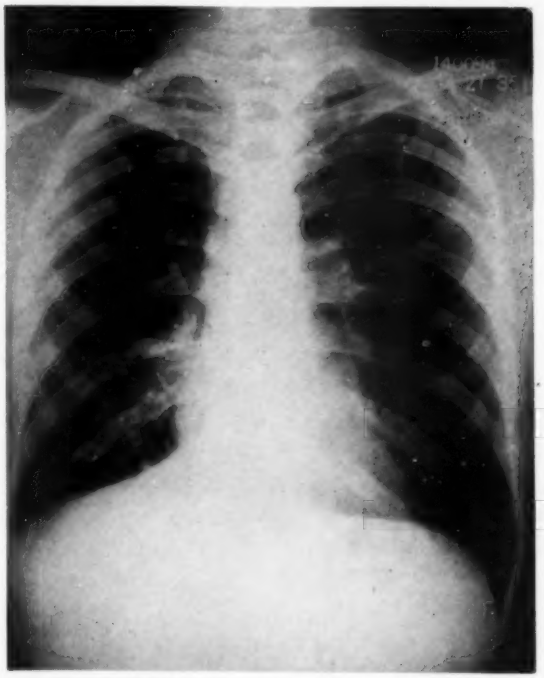

FIG. 3. Case 1. Tuberculous ulcer of the bronchus with reinflation following atelectasis (Fig. 2), and recurrence of obstructive emphysema. On December 27, 1935, the breath sounds were the same as at the time the films of Figure 1 were taken. At roentgenoscopy the same wide respiratory displacement of the calcium shadows was noted. Comparison with Figure 2 will show that many of the calcium shadows have reappeared but they are not as widely separated as on Figure 1, indicating that the right lower lobe was not as greatly distended.

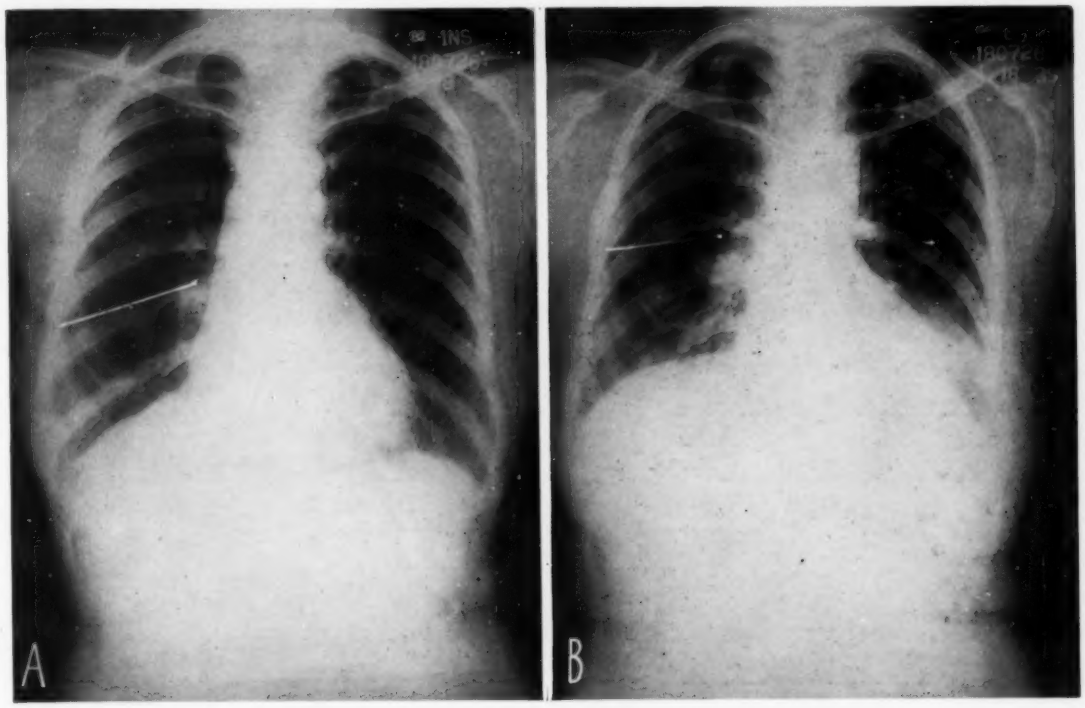

Fig. 4. Case II. Foreign body in the bronchus with obstructive emphysema of the right middle lobe. *A*, inspiration; *B*, expiration (January 18, 1939). At roentgenoscopy wide respiratory movement of the lung markings in the region of the right middle lobe was immediately noted. On the films this movement can be detected only by the abnormal change in position of the interlobar fissure between the right upper and middle lobes on inspiration and expiration. The interlobar pleura, clearly seen on the original films, has been retouched on the prints. This fissure is farther from the diaphragm on expiration than on inspiration (see Fig. 6). The distortion of the bronchial shadows in the right lower lobe by the overdistended right middle lobe can be clearly seen on the expiration film.

chus. A small piece of this tissue was removed which on pathological examination showed changes consistent with tuberculosis.

On December 27, 1935, the breath sounds were the same as on admission. Roentgen examination (Fig. 3) showed reinflation of the right lower lobe with reappearance of the calcium shadows, but their position suggested that the lobe was not as distended as it was originally. At roentgenoscopy abnormally wide respiratory movements of the calcium shadows were observed as at the first examination.

The patient returned home, was treated for tuberculosis and is now practicing his profession.

Case II. A woman, aged sixty-three, four weeks before admission, was eating soup and bread when she suddenly felt something in her trachea. She coughed but could not bring it up. The coughing continued during the day but not at night. A roentgen examination was made elsewhere and was interpreted as negative.

Fig. 5. Case II. Photograph of the piece of bone which was projecting from the right middle lobe bronchus at bronchoscopy.

On admission diminished breath sounds were present at the right base. Roentgenoscopic examination showed wide respiratory movement

of the lung markings in the region of the right middle lobe. The bronchovascular structures did not approach each other as the diaphragm rose on expiration, and the right middle lobe did not seem to deflate. There was no displacement of the heart or flattening or limitation of the diaphragm.

Films taken on expiration and inspiration (Fig. 4 *A* and *B*) show wide displacement of the interlobar fissure between the right upper and middle lobes and distortion of the right lower lobe bronchial shadows along the heart from pressure of the undeflated middle lobe. These findings were interpreted as evidence of obstructive emphysema of the right middle lobe consistent with a foreign body in the right middle lobe bronchus.

At bronchoscopy a piece of bone was seen in the right lower lobe bronchus with its edge presenting toward the bronchoscope, apparently projecting from the right middle lobe bronchus. It was easily removed (Fig. 5).

Roentgen examination of the patient the day following bronchoscopy showed the right middle lobe to be inflating and deflating normally (Fig. 6 *A* and *B*).

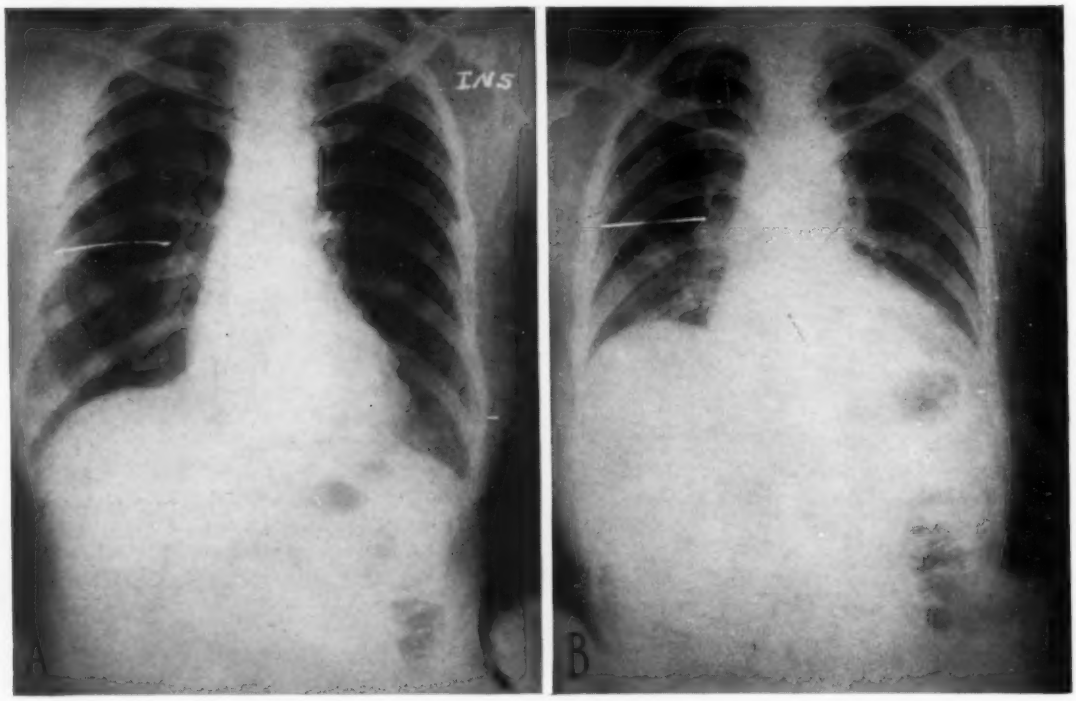

FIG. 6. Case II. Normal lung physiology after the removal of a piece of bone from the right middle lobe bronchus. *A*, inspiration; *B*, expiration (January 20, 1939). The interlobar fissure is closer to the diaphragm on expiration than on inspiration (compare with Fig. 4). At roentgenoscopy the lung markings at the right base approached each other normally. The distortion of the right lower lobe markings on expiration is no longer present.

COMMENT

At roentgenoscopy the numerous healed calcified tuberculous lesions in Case I (tuberculous ulcer of the bronchus) made very good landmarks so that abnormally wide displacement of the right lower lobe structures parallel with and equal to the displacement of the diaphragm was instantly noticed. In Case II (foreign body in the right middle lobe bronchus) no landmarks of calcium density were present but the abnormal movement of the lung markings of the right middle lobe and their failure to approach each other as the diaphragm rose were easily noted. In neither case was there displacement of the mediastinum or limita-

tion of the diaphragm. In both, however, increased radiability of the involved lobe in comparison with the rest of the lung at expiration was apparent but it was not as striking as the movement of the lung structures described above.

On films taken at inspiration and expiration the displacement of the lower lobe structures can be clearly shown in Case I (Fig. 1 *A* and *B*) because of the calcium shadows. In Case II such convenient landmarks were not present, and the displacement of the lung markings so clearly seen on the fluoroscopic screen is recognizable on the films taken at inspiration and expiration only by the remarkable displacement of the shadow of the horizontal fissure between the right upper and middle lobes (Fig. 4 *A* and *B*). The low position of this fissure at deep inspiration suggests that the foreign body was interfering with the ingress of air almost as much as with its egress. A preliminary study of a small series of apparently normal chests at inspiration and expiration was made to determine the respiratory movement of this interlobar fissure with reference to a fixed point on the chest (the lower margins of both first ribs posteriorly). This seems to show that the movement of the fissure varies greatly in different individuals. In the small series thus far examined it varied from 0 to 2.7 cm., the latter figure being 69 per cent of the movement of the dome of the diaphragm (3.9 cm.) in that case. The average movement of the horizontal fissure appears to be about one-third that of the diaphragm. This would indicate that more air passes into and out of the lower than the upper half of the lung. The same impression is given by a comparison of the density of the upper and lower halves of the lung fields on deep inspiration and forced expiration.

Abnormally wide respiratory excursion of the lung markings might be expected from bullae of the lower part of the lung. I have recently seen a case in which such phenomena were observed. The detection of bullae on the film in many cases should serve to make the interpretation clear. However, the diagnosis of obstructive emphysema, which implies obstruction of a main bronchus, must be based upon a correlation of these roentgen signs with the history and the physical findings. Nevertheless, abnormally wide respiratory displacement of the markings of the lower part of the lung indicates that a portion of the lung is not deflating properly. In view of Macklin's[6,7,8] work on the importance of the lengthening and shortening of the bronchi with respiration, it seems possible that disease resulting in a disturbance of that function might interfere with deflation and inflation and thus give rise to abnormal movement of the bronchial shadows.

SUMMARY

The degree of distention of the involved lobe in obstructive emphysema may not be sufficient to cause respiratory displacement of the mediastinum and depression of the diaphragm. Two cases are reported in which obstructive emphysema of the right lower lobe and of the right middle lobe was first detected at roentgenoscopy by noting abnormal respiratory displacement of the lower lung structures parallel with the movement of the diaphragm.*

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THE ROENTGENOLOGICAL ASPECTS OF AN EPIDEMIC OF ACUTE RESPIRATORY TRACT INFECTION*

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DURING the months from January to May, 1939, there occurred in Philadelphia, as well as in many other localities, both in this country and abroad, an epidemic of an acute respiratory tract infection. This epidemic resembled in many respects outbreaks that have become almost an annual occurrence. The epidemic of 1939, however, was characterized by two distinctive features, namely, the large number of the population affected and the relatively mild character of the disease.

Our interest in this epidemic resulted from a report by one of us (H. A. R.) of a small series of cases that occurred sporadically during 1938. From 2 patients of this series a filtrable infectious agent was recovered that may have been etiologically related to the patient's infection. Thinking that possibly the sudden outbreak of acute respiratory tract infections that occurred in January, 1939, might be due to the same etiological agent, it was decided to conduct a careful clinical and roentgenological study of these cases. The clinical aspects of this investigation have been prepared for publication by Reimann and Havens.[2] The present paper deals with the roentgenological features of the epidemic.

METHOD OF STUDY

The patients included in this investigation were purposely confined to a select group of individuals, being medical students, nurses and interns of the Jefferson Medical College and Hospital. Such a selection offers certain definite advantages. The patients studied were confined to a rather narrow age limit. They were young, healthy, active and for the most part free of any intrathoracic pathology that tends to modify or complicate the changes commonly encountered in acute respiratory tract infections. Being subjects of institutional regimen the patients were brought to medical attention much earlier than ordinarily occurs with individuals suffering from a common cold. There is included a large number of mild cases that in the ordinary walks of life would not have had medical care. This has permitted a study of relatively mild forms of acute respiratory tract infection and in most instances at an earlier stage than patients seen in an active private and hospital practice. The intelligence of the group as a whole and their medical training greatly aided in securing excellent cooperation both from a clinical and roentgenological point of view. Thus it was possible to follow the course of the disease until recovery was complete in all instances.

To gain some idea as to the incidence of the disease an investigation was made of the entire personnel of the three groups concerned. Thus the entire number of medical students, nurses of the training school and the intern staff comprised a total of 813 persons. Of this number 407, or 50 per cent, at some time between January and May, 1939, were ill with what was apparently the same disease. We believe that this is approximately the same incidence as occurred in the population at large in Philadelphia and its environs. Of the 407 patients, about 100, or 25 per cent, were sufficiently ill to require hospital care, and of this number 86 were studied roentgenologically. This figure is undoubtedly higher than would apply to the general population since the ready facilities for hospital care afforded this group of individuals unquestionably increased the number receiving such attention. Probably no more than 25

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of the total number, or 16 per cent, required actual hospitalization. This, coupled with the fact that there were no fatalities in the group studied, indicates the relatively mild character of the disease.

The method of study consisted of a careful history and physical examination as soon as the patient applied for medical attention. The appropriate laboratory studies were done and a roentgen examination of the chest made at once. These studies were carried out as early in the disease as possible. Physical examination of the chest was done daily and roentgen examinations were repeated as often as considered advisable by the medical attendant. A final roentgen examination was done in the more severe cases after clinical recovery had occurred.

CLINICAL ASPECTS OF THE DISEASE

Reference to the clinical aspects of the cases studied in this epidemic will tend to orient one regarding the character of the condition under investigation. Reimann and Havens have made a careful clinical analysis of the group of patients studied so that it is necessary here to refer only to some of the outstanding features, especially those having any bearing on the roentgenological phase of the subject.

The disease was primarily an inflammation of the mucous membrane of the respiratory tract, usually of the nose, pharynx and larynx, occasionally including the trachea and bronchi, and in a few instances the bronchioles and lungs. On the basis of this involvement the majority of the patients (87 per cent) were ill with nasopharyngolaryngitis, 7 per cent had in addition tracheobronchitis, and 6 per cent had tracheobronchopneumonia. Constitutional symptoms were present usually in proportion to the extent and intensity of the mucosal inflammation. The clinical course in general was remarkably uniform in most cases differing chiefly in degree or severity. For simplicity in discussion, the cases were classified as mild or ambulatory, moderately severe or bed-fast and severe.

The Mild Form. This group constituted 307, or 75 per cent, of the cases. These patients were ambulatory and usually complained of coryza, nasal obstruction, malaise, frontal headache, weakness, dizziness, sweating and anorexia. There was occasionally dry cough, but rarely fever. These patients were sick but a few days although a number of them had one or two relapses. There were no roentgen studies in any of this group.

Moderately Severe and Severe Forms. About 100, or 25 per cent, of the patients were ill enough to go to bed. Of this number 25 had tracheobronchitis and 25 had tracheobronchopneumonia. Of this group 86 were studied roentgenologically. The clinical diagnosis of tracheobronchitis was made on the basis of the roentgenological findings. The mode of onset was the same as in the mild cases. However, in a day or two the initial symptoms increased in severity and, in addition, there was a generalized aching, pain in the eyeballs, photophobia, with a persistent hacking or paroxysmal cough which often interfered with sleep. Many complained of a dry, raw or sore throat. Gastrointestinal symptoms were not uncommon, anorexia being present in about half the cases, and 12 patients had vomiting and diarrhea.

The temperature was usually elevated and averaged between 38.3° C. (101° F.) and 39.5° C (103° F.). Fever lasted an average of 2.5 days in those without lung involvement, 4.6 days in patients with tracheobronchitis and 8.2 days in those with pneumonia. In the patients with pneumonia the fever was continuously high or occasionally remittent and declined by lysis.

The leukocyte count ranged between 5,000 and 8,000 per cu. mm. of blood. There was often a slight increase in the proportion of polymorphonuclear cells. The sedimentation rate was usually increased. All cultures of the blood were sterile.

Physical signs were found in the lungs only in patients with pneumonia, with the exception of 4 cases of tracheobronchitis in

whom râles or suppressed breath sounds were heard in the hilar areas of the lungs. The physical findings in the lungs consisted of occasional dullness, suppressed breath sounds and invariably râles in one or both interscapular areas, but sometimes confined to one lobe, or to several lobes at the same time or in succession.

The disease with pneumonia lasted from two to seventeen days, averaging 8.2 days. All patients recovered. Convalescence was usually rapid.

ETIOLOGIC STUDIES

This phase of the investigation was of particular interest. The similarity of the clinical course of the disease to several cases from which a filtrable virus was obtained the year before led to the belief that the same agent might be responsible for the present cases. Nasopharyngeal secretions from 11 patients early in the disease were inoculated intranasally into anesthetized ferrets by Dr. Joseph Stokes and Mrs. Shaw. Aside from the absence of the virus of epidemic influenza indecisive results were obtained. Complement fixation tests with influenza virus as antigen made on the blood from 15 patients gave no positive results.

Bacteriologic studies of sputum and nasopharyngeal exudates showed the presence of a number of different organisms none of which was considered to be of etiologic importance. *B. influenzae* was not encountered. There was also a remarkable scarcity of pneumococci.

From an etiological point of view the disease here reported was considered a distinct clinical entity similar to epidemic influenza but caused by a different agent. Many features of the disease such as its epidemiology, close resemblance to other diseases known to be caused by filtrable viruses, the normal leukocyte count and the absence of evident causative bacteria suggest that a filtrable virus is the cause.

ROENTGENOLOGICAL ASPECTS

A roentgen examination gf the chest was requested as a matter of routine in 86 patients in the two groups of moderately severe and severe. The examination for the most part consisted of a posteroanterior and a lateral film of the chest using the usual standard technique employed for this examination. In some instances stereoscopic films were made. In a few of the more severe cases films were made with the mobile unit. This practice was discouraged, however, and whenever the patient's condition would permit they were brought to the Roentgen Department for films to be made in the usual manner.

In accordance with the roentgen findings the series of cases examined was divided into three groups: (1) negative, (2) acute tracheobronchitis, and (3) atypical pneumonia. There were 40 cases in the negative group, 24 patients had an acute tracheobronchitis and 22 had an atypical pneumonia. There was a striking agreement between the clinical and roentgenological findings. Only 4 patients considered negative roentgenologically were diagnosed acute tracheobronchitis clinically on the basis of râles or suppressed breath sounds heard in the hilar areas of the lungs and 2 patients diagnosed acute tracheobronchitis roentgenologically were considered to have pneumonia clinically.

Roentgenologically no diagnostic difficulties were encountered in the recognition of the negative cases and those with pneumonia. The diagnosis of acute tracheobronchitis, however, afforded opportunity for considerable error as will be subsequently discussed. In using the term tracheobronchitis we are aware that what is seen roentgenologically is only the bronchial manifestations of the disease. Bronchoscopy, however, has so firmly established the concomitant involvement of trachea and bronchi in acute and chronic infections of the respiratory tract that roentgenographic diagnoses are usually reliable.

ACUTE TRACHEOBRONCHITIS

The diagnosis of a tracheobronchitis roentgenographically is one that may afford considerable difficulty and often per-

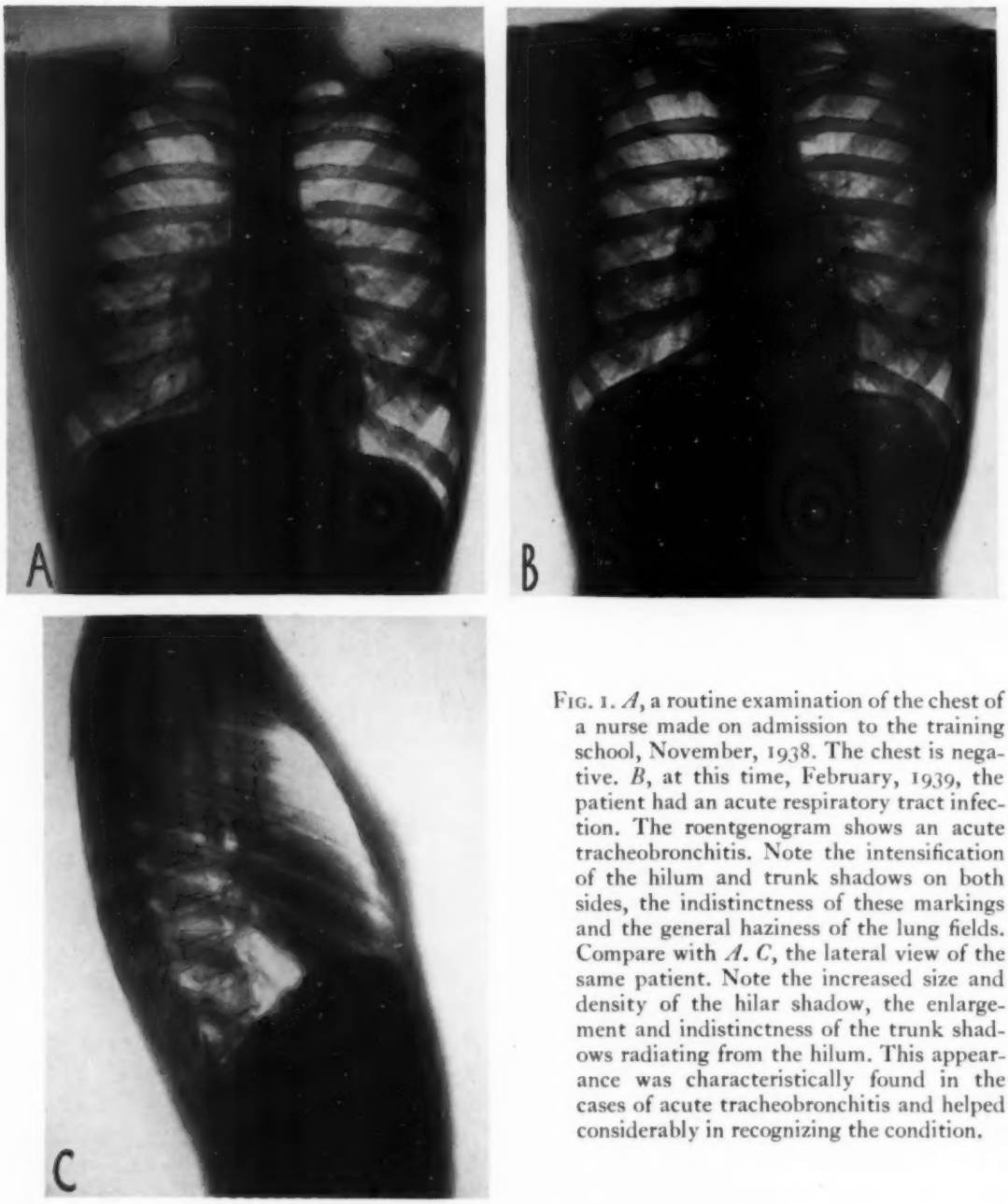

FIG. 1. *A*, a routine examination of the chest of a nurse made on admission to the training school, November, 1938. The chest is negative. *B*, at this time, February, 1939, the patient had an acute respiratory tract infection. The roentgenogram shows an acute tracheobronchitis. Note the intensification of the hilum and trunk shadows on both sides, the indistinctness of these markings and the general haziness of the lung fields. Compare with *A*. *C*, the lateral view of the same patient. Note the increased size and density of the hilar shadow, the enlargement and indistinctness of the trunk shadows radiating from the hilum. This appearance was characteristically found in the cases of acute tracheobronchitis and helped considerably in recognizing the condition.

mits of much controversy. When one attempts to differentiate between an acute and a chronic tracheobronchitis the complexity of the problem may be considerably enhanced. For this reason it seems advisable to consider this subject in some detail and to discuss the criteria used in making a diagnosis of acute tracheobronchitis in this series of patients.

The recognition of a tracheobronchitis is based upon an increased prominence of the hilum and trunk shadows of the lungs. In the normal individual there is considerable variation in the density of these shadows. There is further variation with the age of the patient, the size of the individual, the density of the breast shadows in the female the character of the roentgen exposure and

the phase of respiration during which the exposure is made, also the position of the patient whether recumbent or erect and whether or not the films are made with a mobile unit. All these factors must be taken into consideration in arriving at a diagnosis of tracheobronchitis.

As is well known, the hilum and trunk shadows of the lungs are made up chiefly of the pulmonary blood vessels and lymphatics with a minimum amount of shadow cast by the bronchial tree. Every roentgenologist must have fixed in his mind a standard for the normal chest as regards the various shadows that make up this complex picture. This concerns the relative size and shape of the thoracic cage, the size and contour of the mediastinal and cardiac shadows, as well as the shadows produced by the hilum and linear markings of the lungs. Such a standard can only be acquired by experience. Roentgenologists of many years' experience, however, have found it necessary to modify their individual standard from time to time as improvement in roentgen equipment, permitting of more rapid exposures, improvements in intensifying screens and in celluloid film have added a wealth of detail to roentgenograms of the chest that was not present twenty-five years ago. All shadows have become more sharply defined and in addition there has been a marked increase in the number of the lung markings. This applies particularly to the peripheral portions of the lungs where formerly no lung markings were visible in the normal chest. An experience gained in the annual routine roentgen examination of a large number of healthy medical students has greatly modified our own conception of the appearance of the normal chest.

With the increased detail that is now apparent in chest films the recognition of a tracheobronchitis has become more difficult. Bearing in mind the fact that the pulmonary shadows are for the most part produced by the blood vessels, one must differentiate an increase in these vascular markings from the peribronchial and perivascular shadows produced by a tracheobronchitis. This is not always easy and again requires experience for proper interpretation. The linear markings when due to blood vessels are usually sharp, branch-like shadows that extend radially from the hilum with the largest vessels extending toward the bases. These vessels stand out sharply with clear spaces between them. On the left side the basal vessels are largely obscured by the cardiac shadow but on the right a definite clear space can be noted between the right border of the heart and the vessels extending down into the lower lobe. When the vessels are seen axially there is noted a rounded homogeneous shadow approximately 3 to 5 mm. in diameter. These shadows are present in the hilum and the regions immediately adjacent to the hilum. They become smaller with their distance from the hilum and are absent in the peripheral portions of the lungs.

In a chronic tracheobronchitis the hilum shadows are distinctly increased in size and density. There is a loss of detail of the individual structures making up the hilum shadow. The trunk markings radiating outward from the hilum are also distinctly increased in size and density. There is a loss of the clearcut outlines of the blood vessels and the shadows tend to merge with each other. Again the shadows are heaviest in the bases and there is frequently noted an obscuration of the space between the right border of the heart and the adjacent blood vessels.

In acute tracheobronchitis (Fig. 1*B*), there is the same general appearance as found in the chronic condition with the exception that the shadows are much less well defined, present a distinctly blurred appearance, are less dense and of a softer character, and there often is noted a very small soft mottling in the pulmonary tissues about the hilar area. Of considerable importance is the generalized haziness one finds throughout the lung field giving the impression of an underexposed roentgenogram. This is evidently the result of an active congestion of the interstitial blood

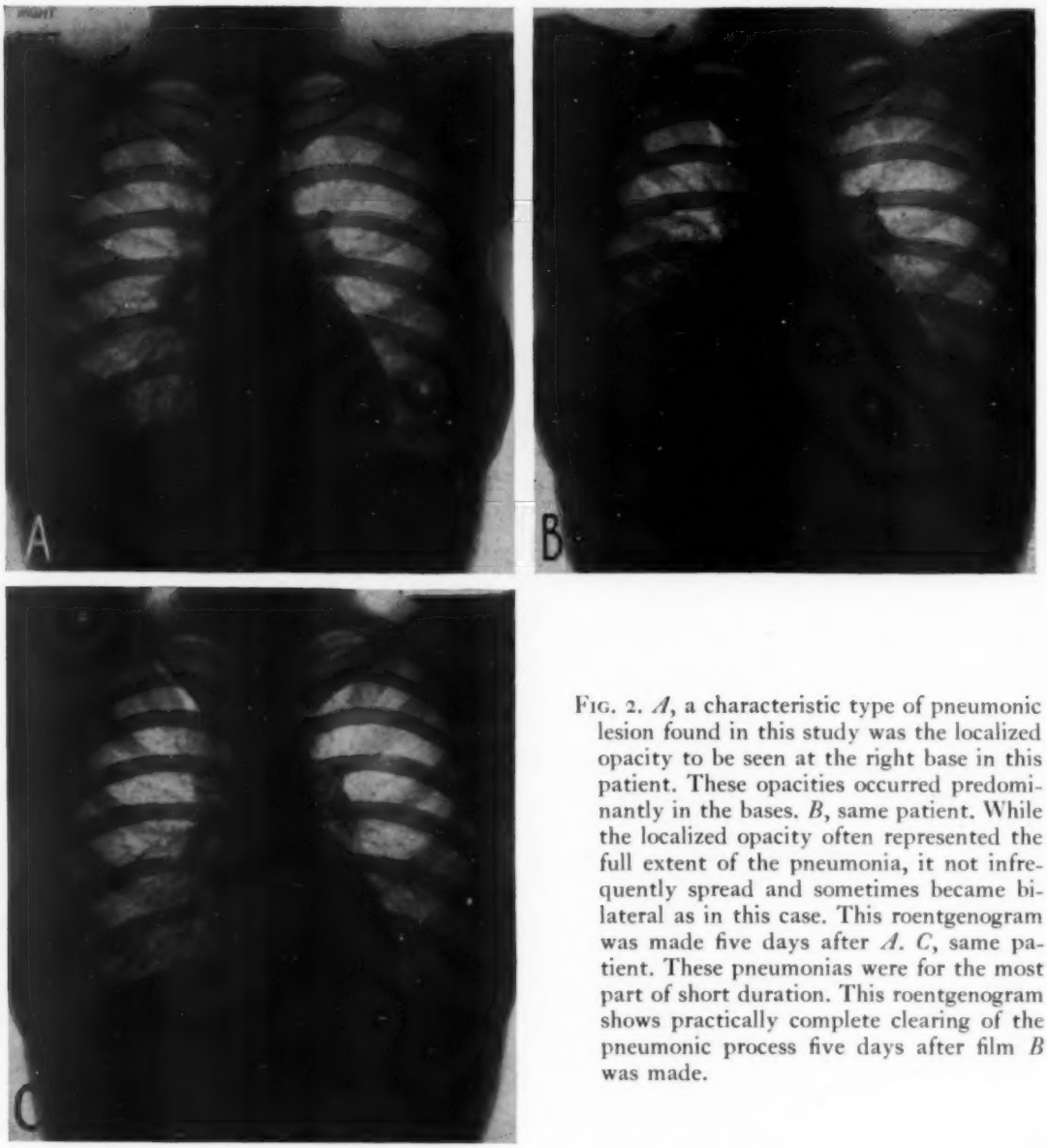

FIG. 2. *A*, a characteristic type of pneumonic lesion found in this study was the localized opacity to be seen at the right base in this patient. These opacities occurred predominantly in the bases. *B*, same patient. While the localized opacity often represented the full extent of the pneumonia, it not infrequently spread and sometimes became bilateral as in this case. This roentgenogram was made five days after *A*. *C*, same patient. These pneumonias were for the most part of short duration. This roentgenogram shows practically complete clearing of the pneumonic process five days after film *B* was made.

vessels throughout the lungs. In the present study we found the lateral view of the chest of considerable value in the recognition of acute tracheobronchitis, also in differentiating it from the chronic variety and from exaggerated vascular markings. In this view (Fig. 1*C*), there was noted a marked increase in the density of the hilar shadow which was also increased in size. There was a complete absence of any definition and the various structures comprising this region could not be differentiated. The edges of the hilum were quite blurred and indistinct and there were nodular densities suggesting the presence of enlarged lymph nodes. We were often able to make a diagnosis of acute tracheobronchitis from the lateral view alone and in many instances in which the appearance of the posteroanterior film was indecisive the lateral view served to establish the diagnosis.

In the group of individuals under investigation there were several factors that aided materially in arriving at a diagnosis of an

acute tracheobronchitis. In the first place, the study was restricted to a rather limited age group—young adult life, the majority of the patients being between the ages of eighteen and twenty-eight. Only 7 were more than twenty-eight years of age. This is the most favorable age period for a roentgenological study of the chest. In children the disproportionately large cardiac and mediastinal shadows, the immature and incomplete development of the intrathoracic structures, and the less likelihood of having the films made uniformly in full inspiration produces a great variation in the roentgen appearance of the chest in normal children. After thirty years of age the lung picture begins definitely to change as the result of increasing age and the effects of intercurrent disease. The influence of increasing weight begins to make itself manifest at this time. There is a marked increase in the lung changes incident to frequently recurring respiratory tract infections and chronic bronchosinusitis. At this age chronic pulmonary emphysema begins to manifest itself, and the lung changes resulting from allergy are likely to appear. Cardiovascular diseases increase in frequency after the age of thirty and greatly modify the roentgen appearance of the intrathoracic structures, particularly the hilum and trunk shadows of the lungs. The second factor that favorably influenced this study was the fact that the persons examined were for the most part healthy, active individuals. There were several patients with healed tuberculous lesions and a number with chronic tracheobronchitis and some in whom the vascular markings of the lungs appeared unduly prominent. The incidence of these complicating factors, however, was undoubtedly much less than would be found in any unselected group of individuals. Unquestionably the greatest help in the recognition of an acute tracheobronchitis in this group of patients was derived from the fact that the majority of them had had previous roentgen studies of the chest. This was particularly true of the nurses who have a routine examination of the chest on admission to the training school and subsequently at stated periods during training. This added very materially to the accuracy of our observations as the opportunity to compare films made during the epidemic with prior examinations when the individual was not ill (Fig. 1 *A*) enabled us to recognize mild forms of acute tracheobronchitis that undoubtedly would otherwise have been missed. Furthermore, in other instances in which the appearance of the chest suggested an acute tracheobronchitis, comparison with previous films revealed the same appearance, indicating that the changes were not the result of a recent respiratory infection. These were felt to be cases of chronic tracheobronchitis.

We were fully aware of the hazards in making a diagnosis of acute tracheobronchitis. Therefore, in order to check on the accuracy of the original interpretations, the films of the entire series of patients, comprising some 300 roentgenograms, were reviewed independently by three different roentgenologists. Interpretations were rendered without a knowledge of the patient's clinical condition. These readings were then checked against each other and with the original reports and a final summation made in each individual case. While there were many individual differences of opinion the final result checked very closely with the original interpretations. The statistical result was not materially altered by this procedure.

Although many previous clinical and roentgenological studies have been made of sporadic and epidemic cases of acute respiratory tract infections little attention has been given to the roentgenological recognition of acute tracheobronchitis. This we feel is a distinct feature of the disease entity under discussion, and an attempt should be made to recognize these cases. This tends to segregate the cases in which the disease is limited to the upper respiratory tract, on the one hand, from those in which the disease has invaded the parenchymal tissues of the lung to produce a pneumonia. In this pres-

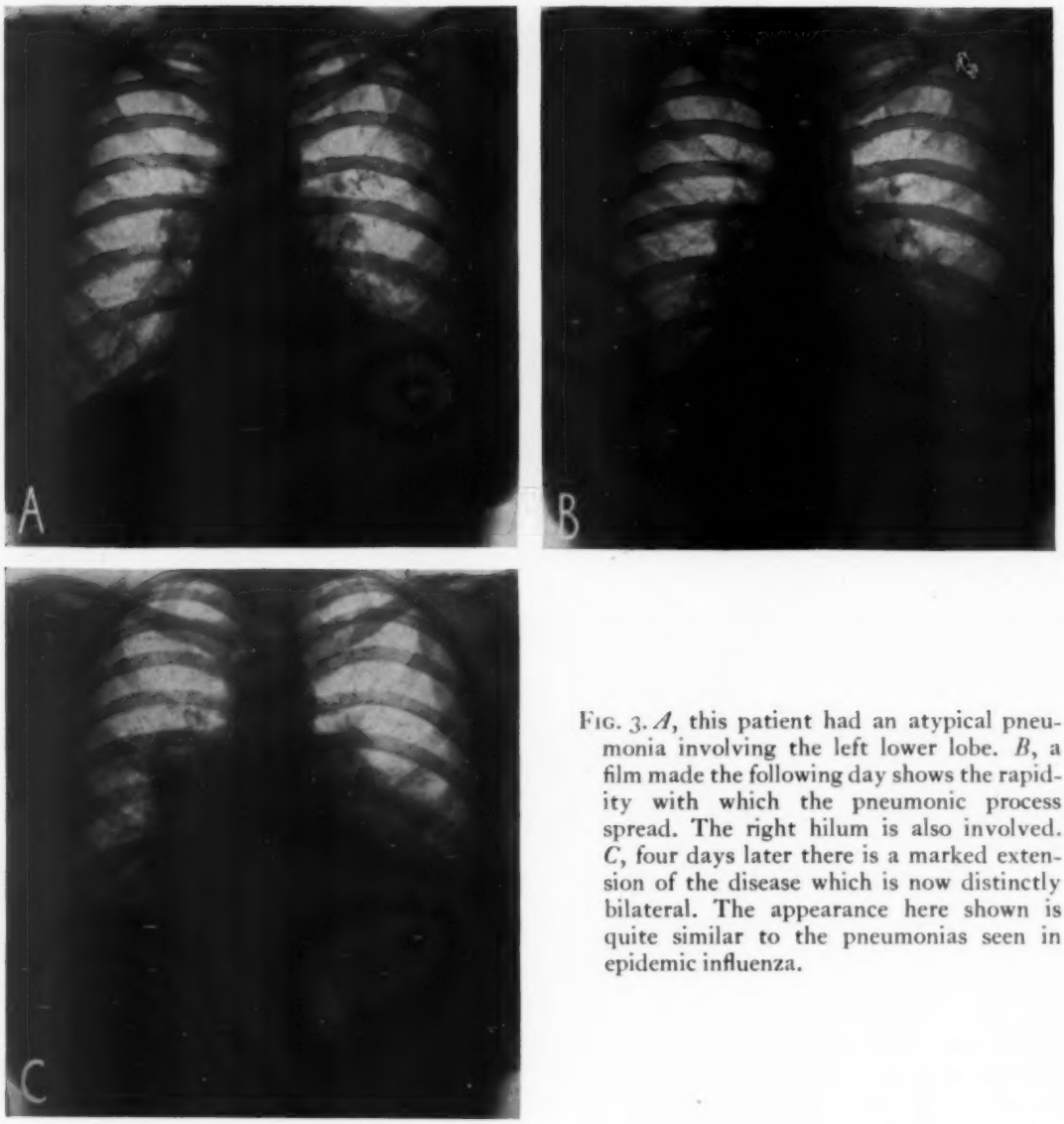

FIG. 3. *A*, this patient had an atypical pneumonia involving the left lower lobe. *B*, a film made the following day shows the rapidity with which the pneumonic process spread. The right hilum is also involved. *C*, four days later there is a marked extension of the disease which is now distinctly bilateral. The appearance here shown is quite similar to the pneumonias seen in epidemic influenza.

ent investigation the clinical diagnosis of acute tracheobronchitis was dependent upon the roentgenological findings in all but 4 cases in which the roentgen examinations were negative but the physical signs indicated involvement of the bronchial tree. The importance, therefore, of recognizing the roentgen changes in acute tracheobronchitis becomes apparent.

ATYPICAL PNEUMONIA

The occurrence of pneumonia in the course of acute respiratory tract infections has engaged the attention of many writers on the subject. The roentgenological aspects have been discussed on many occasions. In 22 patients of the present series there were pulmonary changes sufficient to warrant the diagnosis of pneumonia. A distinctive feature of this pneumonic involvement was the great variability in the type of lesion produced. One of the characteristic lesions consisted of a fairly well localized area of increased density (Fig. 2 *A*) situated in various portions of the lung but occurring predominantly in the lower lobes. The areas while variable in size were never very large, thus differing from the consoli-

dations encountered in lobar pneumonia. Although the inflammatory reaction was localized it was not sharply defined, the opacity tending to merge imperceptibly with the surrounding pulmonary tissues. The areas of involvement varied considerably in density. Again they were never as dense as the consolidations of lobar pneumonia. Such an opacity at times represented the entire extent of the pneumonia, recovery occurring without further extension (Fig. 5 *C*). In other instances (Fig. 2 *B*) the small initial opacity acted as a focus from which the inflammatory process spread to involve a much larger portion of the lung and at times the pneumonia became bilateral.

Another fairly common type of lesion, in contrast to the localized opacity, was a diffuse but not very dense pneumonic process at one base (Fig. 3 *A*). Again this might clear without further extension or spread, either slowly or rapidly (Fig. 3 *B*). The condition at times remained unilateral but just as frequently became bilateral (Fig. 3 *C*).

In several cases the pneumonia showed a predilection for the hilar region, either unilateral or bilateral. These patients presented a roentgen picture quite similar to the pneumonia seen in epidemic influenza (Fig. 3 *C*), in which the predominant pneumonic involvement occurs in the hilar regions with radial extension outward into the peripheral portions of the lungs.

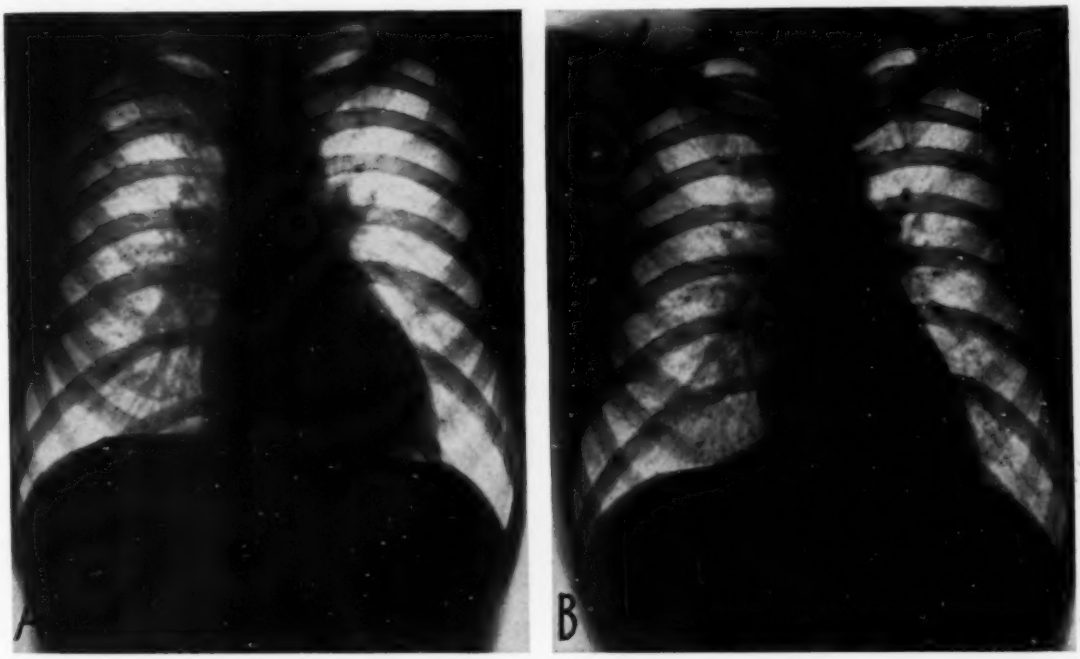

Fig. 4. *A*, the pneumonia was often distinctly unilateral as in this patient who had an atypical pneumonia involving the entire right lung indicated by the marked increase in the size and density of the hilum and trunk shadows and the diffuse haziness and mottling throughout the right lung. *B*, the disease subsequently became bilateral as shown in this roentgenogram made six days after *A*.

At times the pneumonic reaction was indicated by a barely perceptible haziness, the recognition of the pneumonia depending upon the diffuse mottling in the involved area (Fig. 4 *A*). This was either unilateral or bilateral (Fig. 4 *B*). As most of the patients were examined very early in the course of their disease, roentgenological changes were evident in several cases before the appearance of physical signs warranted the clinical diagnosis of pneumonia. In several instances in which the roentgen

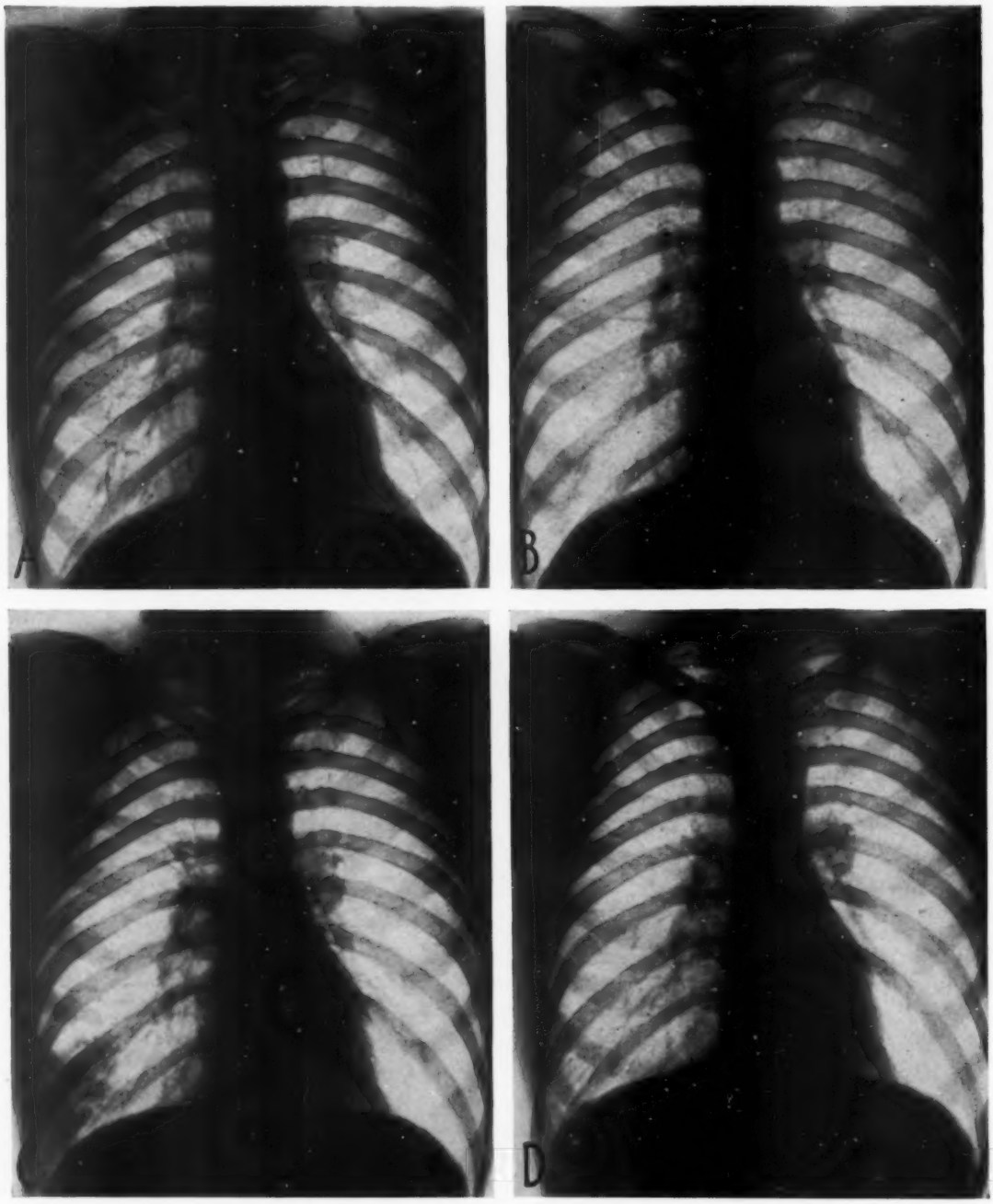

FIG. 5. *A*, this patient had an acute respiratory tract infection in January, 1939, from which he made an incomplete recovery. The chest at this time was negative. *B*, the patient had a relapse about two weeks later. A film made at this time showed a faint indefinite density at the right base not sufficient to warrant a diagnosis of pneumonia. It was suggested, however, that the patient would probably develop a pneumonic process at this site. This shows the value of previous films for comparison. *C*, an examination made a week later shows a definite localized pneumonia at the right base as predicted. This was the entire extent of this pneumonic involvement. *D*, nine days later the chest was again negative.

changes were not sufficient to make a diagnosis of pneumonia, we were able to suggest the probably development of pneumonia in a certain location (Fig. 5 *B* and *C*) again in the absence of physical signs. These opacities (Fig. 2 *A*, *B* and *C*) ran a comparatively benign course tending to clear in from a week to ten days. In several cases, however, the disease was protracted over a period of several weeks. As has been frequently observed, the roentgen changes tended to persist for some time after the apparent recovery of the patient. In a number of instances in which previous studies were not available, it was apparent from the follow-up roentgen examinations that the recent acute process had been superimposed upon a pre-existing chronic tracheobronchitis. No pulmonary or pleural complications occurred in any of these patients and all recovered.

There seems at times some difficulty in giving a name to these minor opacities in the lung. It is apparent from the literature that this difficulty is more or less universal among roentgenologists. There is such a variety of terms used to describe these lesions that the situation has become quite confusing and one never knows what manner of lesion is being discussed. The use of the term pneumonitis has come to be used rather loosely and at times one does not know precisely what is meant. The term pneumonitis is often employed in the presence of a small pulmonary opacity which is believed to be relatively benign in character in order to differentiate it from the more serious lobar types of pneumonia. This use, of course, is not justifiable since the terms pneumonia and pneumonitis are synonymous, having no reference to the severity of the lesion. Again the term pneumonitis is often used to denote the inflammatory nature of a pulmonary lesion that appears to be of low grade activity to distinguish it from a neoplastic process. Ramsay and Scadding[4] have recently suggested the term "benign circumscribed pneumonia" to describe the transitory opacities occurring during the course of acute catarrhal conditions of the respiratory tract. Many of the lesions in our series did not conform to this descriptive term. We have come in recent years to designate these lesions as atypical pneumonias, taking as a typical pneumonia the lobar consolidations produced by the pneumococcus.

It is important to give consideration to the point as to whether the pulmonary opacities as observed in this study represent a complication or are a part of the disease itself. Scadding,[5] in studying a series of cases of proved virus influenza, came to the conclusion that the virus infection itself extended only as far as the bronchioles and that when a pneumonia occurred it was always the result of a complication of bacterial origin. In the present series of cases we are of the opinion that the pulmonary opacities are a part and not a complication of the disease. No convincing evidence could be obtained that any bacteria found in the sputum were responsible for the pulmonary lesions. The similarity of this disease to other virus infections of the lungs gives rise to the thought that this epidemic was due to a filtrable virus.

SUMMARY

1. A clinical and roentgenological study was made of an epidemic of acute respiratory tract infection occurring in Philadelphia during the months from January to May, 1939.

2. A brief résumé is given of the clinical aspects of the disease and the possible etiology is discussed.

3. Detailed consideration is given to the roentgenological features of the epidemic. Roentgenologically the disease manifested itself as either an acute tracheobronchitis or an atypical pneumonia. Of 86 cases having roentgen studies, 24 had an acute tracheobronchitis and 22 had an atypical pneumonia.

4. The epidemic was characterized by two distinctive features, namely, the large number of the population affected, approx-

imately 50 per cent, and the relatively mild character of the disease. The disease resembled epidemic influenza in many respects, but was caused by a different agent. It represents a clinical entity probably due to a filtrable virus.*

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* For discussion see page 383.

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THE ROENTGEN ASPECTS OF NON-PUTRID PULMONARY SUPPURATION*

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NON-PUTRID pulmonary suppuration is a severe from of bronchopneumonia in which necrosis of pulmonary tissue takes place. It has been variously classified as suppurative and as necrosuppurative bronchopneumonia.[1] In a previous report,[2] it was pointed out that until an abscess can be demonstrated, the diagnosis of suppurative rather than simple bronchopneumonia cannot be made roentgenologically. Areas of rarefaction seen within a pneumonic shadow may represent foci of suppuration but differentiation from a resolving pneumonia is impossible from the single film. However, the diagnosis should be considered when these areas persist, become larger or confluent. The definite diagnosis of abscess can be made only when a fluid level is demonstrated.

A. SUPPURATIVE BRONCHOPNEUMONIA WITHOUT ABSCESS

Suppurative bronchopneumonia occurs characteristically as a diffuse process, with infiltrations scattered irregularly throughout one or both lungs. Patchy confluence may occur. Indeed, lobar confluence may be present and produce a roentgen appearance simulating lobar pneumonia. On the other hand, bronchopneumonia is often segmented or localized. This occurs particularly in the presence of a localizing factor such as bronchial obstruction. Occasionally, however, even tenacious mucus mixed with pus lodging in the bronchi or bronchioles may produce obstructive emphysema or atelectasis. In infants particularly, roentgen evidence of lobar atelectasis is common and is due to obstruction by mucus. The atelectatic lobe sometimes shows irregular mottling in the presence of which a presumptive diagnosis of suppuration can be made. Atelectasis often persists after the bronchial lumen has been reëstablished and is then due to the presence of exudate and granulation tissue in the interstitial tissues of the lung which may maintain the lobe in its shrunken state for an indefinite period.

On the other hand, the rôle of obstructive emphysema is important and the subject has been discussed in detail by Snow and Cassasa.[3] An emphysematous bleb may occur and persist until the ball-valve mucus obstruction is relieved. In the presence of infection a small amount of fluid may accumulate and an abscess is simulated.

B. ABSCESS FORMATION

In 1938, approximately 670 cases of pneumonia were admitted to Mount Sinai Hospital. Of these, 162 were considered to be cases of lobar pneumonia. During the same period 53 cases of lung abscess were diagnosed clinically or at postmortem examination. In other words, lung abscess occurred in this Hospital with a frequency of about 8 per cent of that of all pneumonias and 10 per cent of that of non-lobar pneumonia. In a group of 121 cases with a diagnosis of lung abscess admitted in the three and a half years from 1936 to mid-1939, 39 cases were non-putrid and 82 were putrid.

From the point of view of pathogenesis,* non-putrid must be differentiated from putrid abscess. The latter is gangrene of the lung. In its early stages it is localized regularly to one or more bronchopulmonary segments, although occasionally it spreads rapidly into a diffuse process. The early process in non-putrid abscess is primarily

* As in the previous report, the author is greatly indebted to Drs. H. Neuhof, C. B. Rabin, and H. Wessler for the clinical correlation and for a concept of pathogenesis which is so important in the understanding of the disease.

* Read at the Fortieth Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 19–22, 1939.

a diffuse bronchopneumonia, even though it presents itself occasionally as a segmental lesion.

Aseptic necrosis must also be differentiated. This condition is caused by the occlusion of an artery leading to an area of pneumococcus lobar pneumonia with necrosis of the area. The cavity disappears rapidly so that the finding of a cavity in the lung roentgenographically is an incidental one. The course of the disease is unaffected by it.

In 20 cases of non-putrid abscess, 10 showed a single fluid level roentgenographically, 8 showed multiple levels within a localized area of pneumonitis and 2 showed multiple bilateral cavities. When the antecedent process was a diffuse suppuration the abcesses were usually multiple and often bilateral. Solitary and multilocular abscess occurred when the antecedent pneumonia was segmental.

C. MULTIPLE AREAS OF PNEUMONITIS WITH CAVITATION

Cavitation within several areas of a diffuse suppurative bronchopneumonia may be an incidental roentgenographic finding and may have little effect on the clinical course of the disease. It does not necessarily take place in all of the pneumonic areas at the same time. In fact, it is more likely that the pneumonic areas will be found to be at different stages of formation or resolution. While it is probable that, in most cases, an area of rarefaction outlined by a fluid level is an abscess, there is the possibility that, in some cases, an infected emphysematous bleb is present.

CASE I (No. 425928). A. S., female, aged thirty-six, was admitted to the Hospital June 22, 1938. Six months before admission she suffered an attack of bilateral pneumonia for which she was hospitalized elsewhere for three months. After discharge from that hospital a chronic otitis media developed. Her cough continued with expectoration of purulent foul-smelling sputum. At the time of admission a roentgenogram showed numerous areas of pneumonitis. There were several fluid levels within one of those areas in the right lung. The patient died apparently as the result of a metastatic brain abscess.

Postmortem examination (No. 10840) showed chronic multilocular non-putrid lung abscesses in the infra-apical segment of the right lower lobe and the anterior segment of the right middle lobe. Chronic pneumonic infiltrations were found in the right upper, right lower and left lower lobes.

D. SEGMENTAL ABSCESS

Segmental abscess may also be an incidental finding in the serial roentgenographic examination of a case of bronchopneumonia. In 2 cases of this series, an area of rarefaction containing a fluid level was found roentgenographically within a small area of pneumonia. Clinically, the pneumonia passed through a mild course, the cavity disappearing within ten days. However, occasionally, particularly when there is a large solitary excavation, the onset is more acute and the course shorter and more turbulent. When more than one fluid level is present, the roentgen examination does not permit the differentiation of solitary multilocular abscess and multiple abscesses.

CASE II. *Multilocular abscess in a segmental pneumonitis.* J. R. (No. 418520), male, aged fourteen months, white, was admitted to the Hospital on January 3, 1938. The chief complaint was that of fever of two weeks' duration. In July, 1937, the patient was hospitalized for pneumonia, during the course of which the chest was aspirated twice. He was discharged as cured in August, 1937. In December, 1937, he again developed fever and began to cough. These complaints persisted until admission. He became acutely ill with generalized lymphadenopathy and splenomegaly. Physical signs of pneumonia in the right upper lobe were elicited. There were also signs of thickening of the pleura at the left base. Roentgen examination revealed a pneumonic consolidation of the right upper lobe within which there were numerous small areas of transparency. On January 8, 1938, a myringotomy was necessary for an acute otitis media. The temperature remained elevated from the day of admission until January 10 when it dropped to normal and remained so until discharge. Sulfanilamide was adminis-

tered until January 28. The cavitation in the right upper lobe was evident roentgenographically for about eight weeks. On February 28 the chest was practically clear.

Case III. *Large solitary abscess.* C. C. (No. 441914), child, aged two, admitted June 13, 1939. The history was that of fever and upper respiratory symptoms for ten days. There were physical signs of a pneumonic consolidation of the right upper lobe. Roentgenograms on admission to the Hospital showed a large cavity with a fluid level in the right upper lobe. It was impossible to determine whether this was due

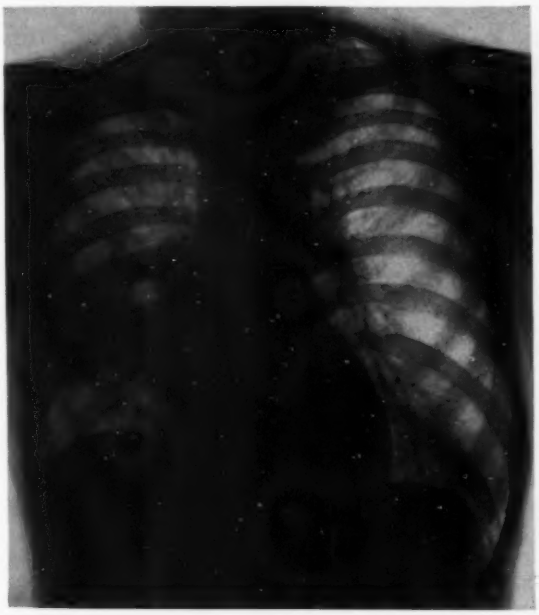

Fig. 1. Case I. Shows an irregular pneumonic infiltration in the lower part of the right upper and the upper part of the right lower lobe. Numerous fluid levels are seen corresponding to a multilocular lung abscess found at autopsy.

to pulmonary cavitation or to a localized pyopneumothorax. Blood culture shortly after admission revealed the presence of *Staphylococcus aureus*. On the day following admission operative drainage was thought necessary and revealed a large non-putrid abscess. The child made a slow recovery due to a complicating furunculosis. The cavity was finally closed with a fat implantation.

Although non-putrid abscess tends in general to spontaneous resolution, occasionally, in the presence of a clinical cure, a

Fig. 2. Case II. Multilocular abscess with segmental pneumonitis which persisted for about eight weeks. The symptoms subsided about six weeks before the infiltration disappeared.

cavity is found to persist for many years or perhaps permanently. The appearance is that of a cyst-like structure within the lung

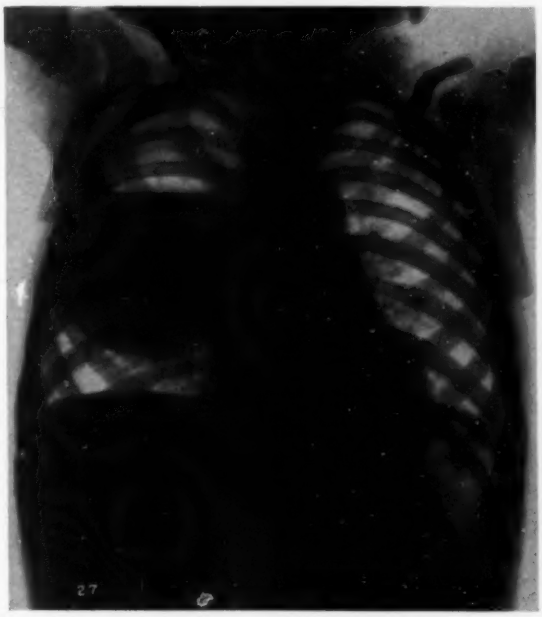

Fig. 3. Case III. Large solitary abscess in the right upper lobe limited to the lung. Operation failed to reveal any pleural encapsulation.

with or without a thin rim of infiltration. Persistent cavities may follow both putrid and non-putrid processes. They often remain asymptomatic but occasionally are the source of further lung disease.

E. PULMONARY ABSCESS WITH PRESENTING PLEURAL COMPLICATIONS

Non-putrid pulmonary suppuration is often presented to the radiologist when pleural complications have already occurred obscuring the underlying pulmonary lesion. In 39 cases of non-putrid abscess, 19 revealed roentgen evidence of considerable pleural fluid at the first examination, and pulmonary abscess was demonstrated only later or at operation. When the roentgenographic appearance is that of a quantity of fluid in the chest, there is no simple roentgen method by which the nature of the underlying disease can be discovered. Hence a certain number of cases of empyema will be found to be due to perforated lung abscess and will reveal a bronchial fistula when the empyema cavity is explored surgically. Roentgenographically, however, this diagnosis usually cannot be made even when the shadow of the abscess is distinct from that of the empyema, because differentiation from encapsulated empyema or pleural exudate is impossible.

Pyopneumothorax is discovered roentgenographically less frequently than empyema. When it is found, complete or encapsulated, a perforated lung abscess can be assumed to be present although not demonstrated apart from the pleural fluid and air. Differentiation of a solitary abscess with a fluid level from localized pyopneumothorax may be difficult or impossible. A shadow with an irregular margin is apt to represent an abscess in the lung. However, when the margin is sharp the differentiation is inconclusive. Pleural collections usually have this appearance and large pulmonary cavities often may be sharply demarcated. Size and the amount of surrounding density are of no great value in differentiation; the large cavities are often intraplumonary while the small fluid levels may represent pleural loculations. Lateral and oblique views are of most value in localizing the process. If the shadow is due to a pleural collection there should be one position in which it is shown as a more or less semicircular shadow, base against the chest wall. Its relationship to the interlobar fissures is also best shown in the oblique and lateral views.

Occasionally, when the pneumonic process is segmental, perforation into the pleura may take place after the cavity has been demonstrated roentgenographically. However, in the case of multiple bilateral abscesses it is not usual for empyema to develop after the pulmonary excavations have been recognized.

The significance of the finding of fluid levels in the chest after Potain aspiration of a pleural effusion has been discussed in the previous report.[2] In general, a satisfactory aspiration should not result in the introduction of air into the pleural cavity so that the demonstration of fluid levels usually indicates loculated pyopneumothoraces due to perforated abscess.

F. BRONCHIAL DISEASE

Since purulent bronchitis with destruction of the elastic tissue of the bronchioles is a constant feature of suppurative bronchopneumonia, bronchial dilatation occurs regularly, often within a few weeks. These changes were discussed in the previous report.[2] It should be repeated that mild bronchial dilatation is not necessarily permanent. Many of the cases studied showed restoration to normal within one year. Recurrence of the pneumonia, persistence of the preceding disease and of atelectasis increase the frequency of bronchial dilatation and the possibility of permanence. The simple roentgen examination does not ordinarily suffice to permit the definite diagnosis nor the extent of bronchiectasis. Only the nonspecific shadow of the peribronchial pneumonia is visualized.

CONCLUSIONS

Non-putrid pulmonary suppuration differs from simple bronchopneumonia by the occurrence of necrosis of the pulmonary parenchyma. The cases may be grouped into diffuse suppuration without abscess, segmental abscess, and multiple abscesses. About 50 per cent of the cases of non-putrid abscess reach the radiologist when pleural complications have already occurred which obscure the pulmonary lesions. A roentgenological diagnosis of the underlying abscess is then not possible unless air and fluid are present in the pleural cavity. In this case the presence of a perforated abscess can be inferred.

In a group of 20 cases of non-putrid pulmonary abscess in which fluid levels were shown, 50 per cent showed a single level, 40 per cent numerous levels within a segmental pneumonia, and 10 per cent multiple levels in a diffuse bilateral pneumonitis. This does not give a correct estimate of the incidence of the diffuse disease because many cases are not recognized clinically whether cavitation is present or not. Cavitation is recognized often only by routine serial roentgen examination of cases of mild or moderately severe bronchopneumonia in which resolution is taking place slowly. It is believed that in some cases an infected emphysematous bleb is present rather than a true abscess. Occasionally the abscess cavity persists and is converted into a pseudo-cyst if the inflammatory process subsides.

The bronchial changes which occur regularly in non-putrid pulmonary suppuration are also reviewed briefly.*

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* For discussion see page 383.

BASAL EXUDATES OF SUBPHRENIC ORIGIN*

By L. R. SANTE, M.D.
ST. LOUIS, MISSOURI

EVERY roentgenologist has been confronted with the problem of determining whether basal lesions of the pleural cavity have their inception in the chest or whether they have their origin in subdiaphragmatic infection. The purpose of this paper is to point out the conditions which may cause conflicting opinion in this region and to emphasize the procedures which are of value in their differential diagnosis. Special reference will be made to pneumoperitoneum examination of the subphrenic space for subphrenic abscess as a possible source of thoracic infection.

Basal shadows in the lung field most frequently have their origin within the pleural cavity. These are usually due to:

1. Pneumonic consolidation of the lower lobes.
2. Pyogenic destruction of lung tissue by acute lung abscess.
3. Atelectasis from complete obstruction of lower lobe bronchi.
4. Indurative fibrosis from chronic lung suppuration associated with bronchiectasis.
5. Bronchiogenic malignancy.
6. Pleural exudates—general and local.

FIG. 1. Artificial pneumoperitoneum for demonstration of subphrenic abscess. Only a small amount of air is necessary if the condition is acute. In the upright position the air is seen beneath the left diaphragm; air does not enter the right subphrenic space indicating the pleural exudate is associated with subdiaphragmatic infection. The condition followed a ruptured infected appendix.

Correlation of the clinical symptoms with roentgenological findings, in most instances, affords the determining factor in the differential diagnosis. The history of fever and other signs of infection at once separate the infections from other conditions of non-inflammatory origin such as cancer of the lung and atelectasis. The character of the fever alone may differentiate between an acute pneumonic process and more chronic type of septic infections such as lung abscess, emphysema and chronic bronchiectasis. A single point in the history such as the duration of the illness may be the all important factor in the differential diagnosis between pneumonia and acute lung abscess or pleural exudate. An extended duration of illness and lack of fever may be the determining factor in the diagnosis of malignant disease of the lung. Correlation with other clinical symptoms such as cough and expectoration may suggest the diagnosis of bronchiectasis, confirmed later with lipiodol injection.

Such correlation may only serve to narrow the diagnosis down to a few possibilities, however, and the ultimate differentiation may require extraordinary methods of examination. Every available maneuver should be resorted to before extraordinary procedures are instituted for diagnostic purposes. Roentgenographic examination should be made with the patient in upright as well as the recumbent posi-

* Read at the Fortieth Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 19–22, 1939.

tions, lying first on the affected side and then on the opposite side in lateral decubitus position to demonstrate any change in appearance produced by shifting pleural effusion. To determine whether a consolidation of the lower lobe may be due to atelectatis, the patient should be rolled upon the side opposite to that involved and caused to cough in an effort to dislodge the mucous plug. Barium meal and enema will aid in detecting any subphrenic involvement of gastrointestinal origin such as carcinoma rupturing into the subphrenic space.

Roentgenoscopic observation of the movements of the diaphragm may throw some light on the nature of the condition. If the diaphragm is normal in position and shows free movement on respiration, a subdiaphragmatic lesion can be ruled out; if

Fig. 2. Same patient as shown in Figure 1, lying upon *left* side; even in this position air does not enter left subphrenic space.

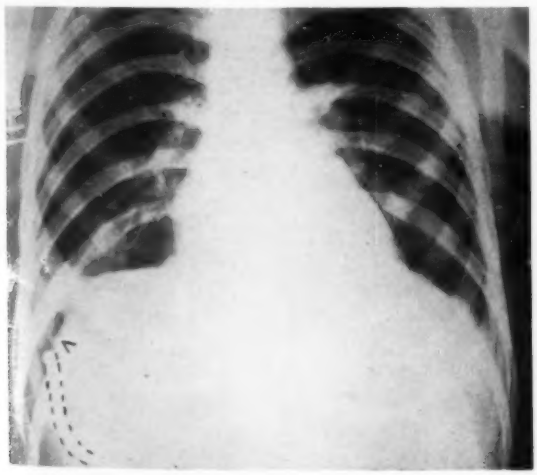

Fig. 3. Same patient as shown in Figures 1 and 2. Drainage of the subdiaphragmatic abscess.

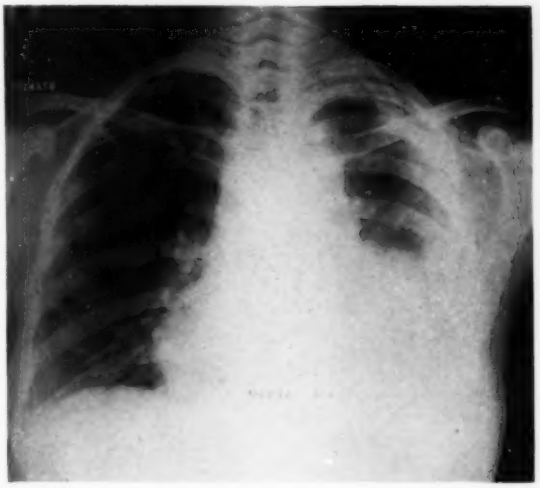

Fig. 4. Pleural exudate of unknown etiology occurring in a diabetic patient. The condition existed for ten or twelve days before a possible subphrenic involvement was suspected.

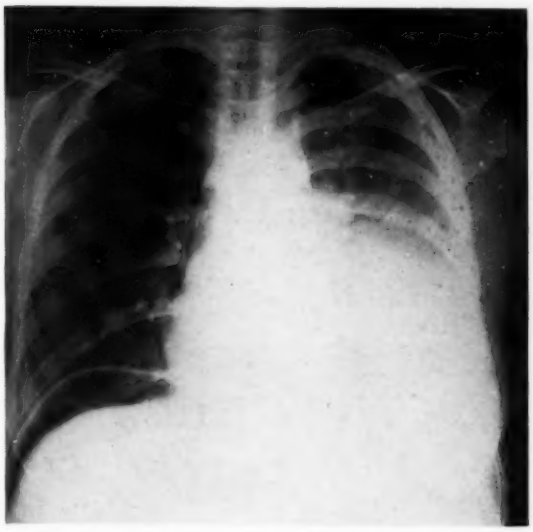

Fig. 5. Same patient as in Figure 4. Pneumoperitoneum was induced and air entered freely into *right* subphrenic space but was excluded from the *left* subdiaphragmatic area indicating left subphrenic abscess as a source of infection for the pleural exudate in the left pleural cavity. The condition was not so acute and more air could be used

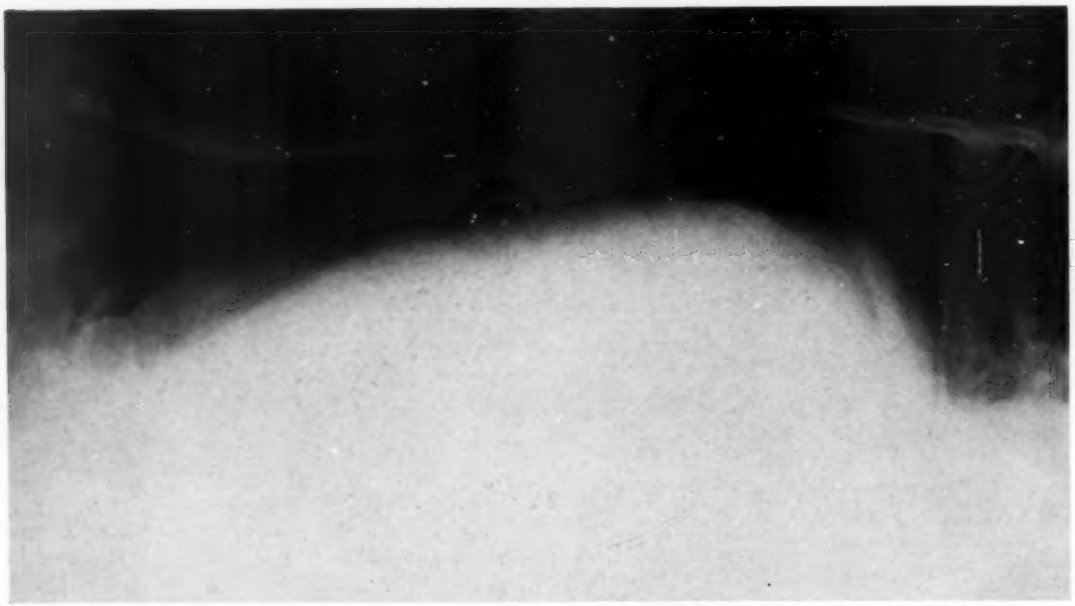

FIG. 6. Same patient as shown in Figures 4 and 5. Patient rolled with *right* side uppermost. Air enters freely into subdiaphragmatic region showing it to be uninvolved.

there is a lesion in the lower lung field and the diaphragm moves freely it can be further stated that there is not only no subdiaphragmatic lesion but that the lesion seen in the lung field is central and does not extend to the periphery of the lung to involve the parietal pleura. The parietal pleura is sensitive and gives rise to pain when involved by infection and other inflammation; the lung parenchyma and visceral pleura are insensitive. Diaphragmatic immobilization (splinting of the dia-

FIG. 7. Same patient as shown in Figures 4, 5 and 6. Patient rolled with *left* side uppermost, showing that even in this extreme position air does not enter subphrenic space. Note exudate in pleural cavity.

phragm) occurs as a response to pain; if this is not present the diaphragm may still show full normal excursion. If the diaphragm is immobilized it merely means that an inflammatory process may be present involving the parietal pleura above or the parietal peritoneum below the diaphragm, but does not differentiate between the two.

Deep-seated infection often gives rise to sympathetic secretion from some adjacent serous surface even without actual spread of the infection to involve the adjoining structure. For instance, lung abscess or interlobar empyema may give rise to sympathetic pleural effusion in the general pleural cavity possibly from engorgement of circulation caused by deep-seated infection. This is likewise true of subdiaphragmatic infection; a collection of pus below the diaphragm may give rise to pleural effusion above the diaphragm even without actual extension of the infectious agent. Under any circumstances, therefore, where there is clinical evidence of infection and a lesion localized to the lower lung field, it may be imperative to determine whether there is a subdiaphragmatic source of the infection.

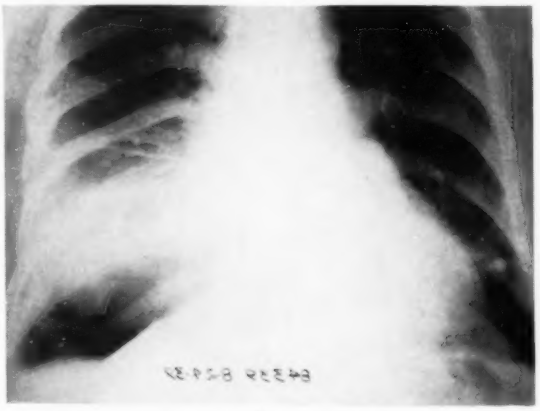

Fig. 8. Ruptured duodenal ulcer followed eight days later by large subphrenic abscess. Note thickened shaggy peritoneal lining of cavity and the pleural exudate above the diaphragm.

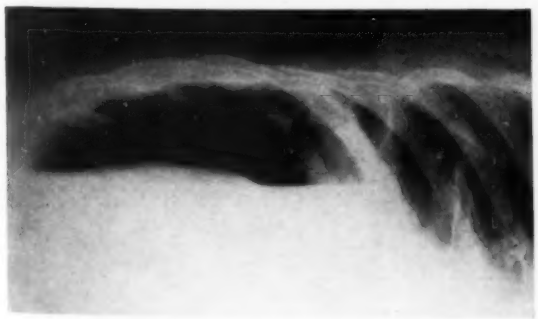

Fig. 9. Same patient as shown in Figure 8. Patient lying with right side uppermost showing extent and limitations of the subphrenic involvement and the shift of fluid both in subdiaphragmatic pocket and in the chest.

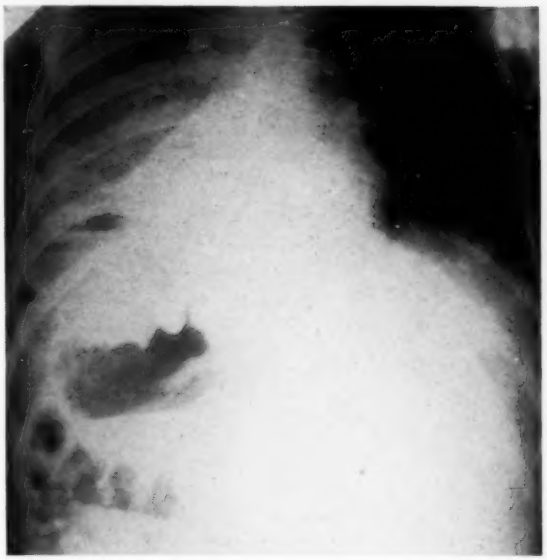

Fig. 10. Left subphrenic abscess from rupture of gastic ulcer. Note associated pleural exudate.

Periodic mention of this subject in the literature is indication that it still presents a diagnostic problem in which no accepted method has come into general use. Elevation of the dome of the diaphragm, immobilization or restriction of excursion have been pointed out as diagnostic criteria but these are only corroborating signs which fail when there is associated pleural exudate. Injection of lipiodol into the subdiaphragmatic abscess cavity after aspiration of pus to determine the extent and location of the cavity has been successful in only a few recorded cases in determining the subphrenic extent of the infection. If

FIG. 11. *Left* subphrenic abscess after splenectomy. Note the fluid level in the subphrenic abscess beneath the left diaphragm, resembling very closely the stomach bubble. Note exudate in pleural cavity.

the cavity of the subphrenic abscess contains gas from bacterial action or other cause the diagnosis may be facilitated but even in these cases the possibility of the abscess being in the pleural cavity above the diaphragm often cannot be determined. Everything hinges on the location of the diaphragm; indeed this still remains the all important question.

In our experience the best procedure for answering this question is the use of artificial pneumoperitoneum as an aid in the exploration of a subphrenic space by roentgenological examination.

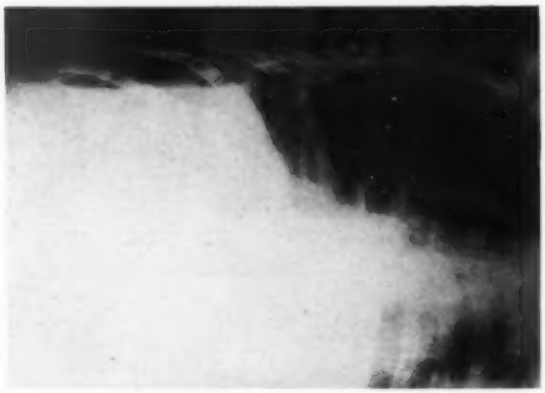

FIG. 12. Subphrenic abscess communicating directly through hole in diaphragm with purulent collection in pleural cavity. Air in chest cavity extends into subphrenic region.

The earliest users of pneumoperitoneum suggested its value in exploring the subphrenic spaces and in a previous communication a number of years ago, the author pointed out the usefulness of this method in the detection of subdiaphragmatic abscess. As a whole, however, the profession seems loath to utilize this method in the presence of infection. We have used it many times, however, and never have seen any unusual consequences.

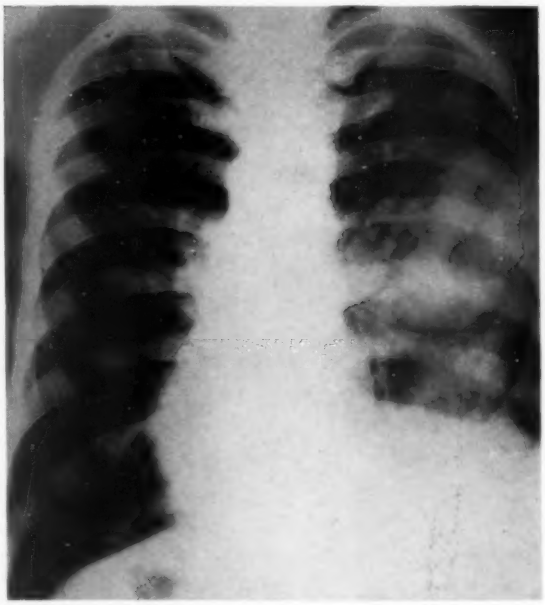

FIG. 13. Subphrenic abscess from purulent appendicitis; ruptured through the diaphragm producing abscess in pleural cavity.

This can be carried out without fear of spread of the infection or danger to the patient. Only a small amount of air is injected into the abdomen using very simple pneumoperitoneum apparatus, consisting of a Potain aspirator pump, lumbar puncture needle and suitable tubing and connectors. A few strokes of a Potain aspirator pump will furnish sufficient air for adequate examination. We have never encountered any difficulty from such small quantities of air. After inflation the patient is rolled upon his side or is supported in an erect position so that the part to be examined is uppermost; in this position the

air finds its way to the subdiaphragmatic region. If this space is clear the under surface of the diaphragm becomes clearly outlined; if there is an inflammatory process beneath the diaphragm this space will be obliterated or adhesions to the underlying structures will be evident. Care must be taken to rotate the patient far over to the side so that any small localized collection may not go undetected (Figs. 1, 2, 3, 4, 5, 6 and 7).

FIG. 14. Lateral view of chest (same patient as Fig. 13), showing tract of pus from the subphrenic region, through the diaphragm, along the interlobar septum to the hilar region. It ruptured into a bronchus and was expectorated.

A wide variety of conditions have been encountered where pleuropulmonary exudates of this sort have their origin beneath the diaphragm. Conditions leading to subdiaphragmatic abscess most frequently arise from perforating lesions of the stomach and duodenum (Figs. 8, 9 and 10) or appendix (Figs. 13 and 14). Occasionally they arise following abdominal operative procedure (Fig. 11). Perinephric abscess may cause infection of the subdiaphragmatic space. Purulent collections beneath the diaphragm may rupture into the chest cavity

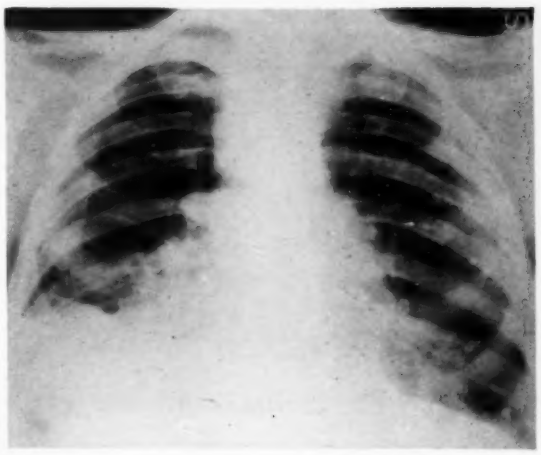

FIG. 15. Infiltrative lesion in the base of the lung occurring in association with carcinoma of the stomach.

producing actual communication between the subphrenic abscess and the pleural cavity (Fig. 12), or they may burrow along the interlobar fissure and rupture into a bronchus causing evacuation of the abscess by expectoration (Figs. 13 and 14). Malignant tumors of the stomach and intestines may perforate into the subphrenic region giving rise to subdiaphragmatic abscess ultimately perforating through the diaphragm and causing pulmonary involvement (Figs. 15 and 16). One must always beware of other pitfalls in diagnosis (Fig. 17).

The information thus obtained is of utmost importance to the surgeon and every roentgenologist should hold himself in readiness to carry out this valuable method of examination. There is no other method

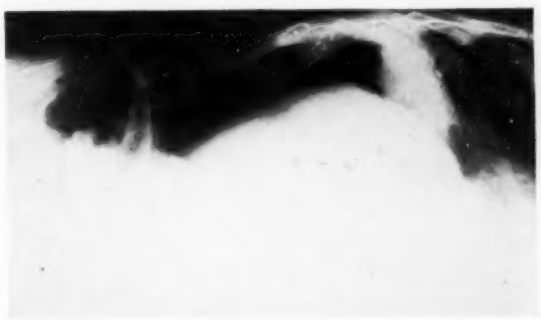

FIG. 16. Same patient as shown in Figure 13, lying on side. Pneumoperitoneum showed metastatic malignant growth involving the diaphragm.

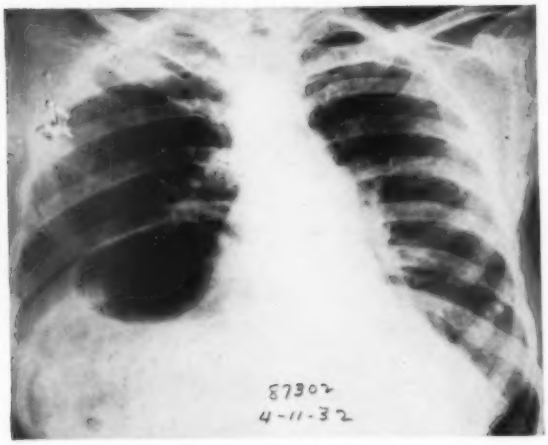

FIG. 17. Eventration of the right diaphragm with scoliosis. A large loop of gas-filled bowel interposed between the liver and the diaphragm could easily be mistaken for subphrenic infection. There was, however, no pleural exudate or other signs of inflammation and the bowel was readily filled with barium solution.

in my experience which will determine so clearly the subphrenic origin of thoracic lesions.

SUMMARY

Ordinary methods of roentgenological examination in a great many instances fail to disclose subphrenic lesions as a basis for conditions found in the thoracic cavity.

Pleural exudates may occur as sympathetic effusions due to adjacent subphrenic abscess or there may be actual communication through the diaphragm between a subphrenic abscess and an empyema cavity. Malignant infiltration and erosion through the intestinal wall may serve as the etiological factor in subphrenic involvement.

After all ordinary methods of examination have failed, artificial pneumoperitoneum may be resorted to as a diagnostic agent without fear of breaking down of adhesions or spread of infection.

By this method air enters freely into the subphrenic region on the uninvolved side but is prevented from entering on the involved side by adhesions resulting from the subphrenic abscess. By no other roentgenological means can this be conclusively demonstrated.*

* For discussion see page 383.

Vol. 44, No. 3

PRIMARY CARCINOMA OF THE LUNG

A ROENTGENOLOGIC STUDY OF 206 PROVED CASES*

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and
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SINCE the appearance of Adler's monograph in 1912, primary carcinoma of the lung has been the object of a vast amount of study and research. Simons' monograph, published in 1937, epitomizes 551 articles collected from the world's literature on primary carcinoma of the lung, and offers a thoroughly comprehensive background for further investigation.

On the basis of the aforementioned work it is permissible to state that the incidence of the disease is increasing, that the only hope of "cure" lies in early diagnosis and prompt institution of the approved surgical treatment, and that early diagnosis, in turn, is based upon the close cooperation of internist, bronchoscopist, and roentgenologist.

Manifestly, there are certain limitations of method in the roentgenologic diagnosis of primary carcinoma of the lung for, as Mattick has expressed it, "there is no single finding or group of findings that is absolutely pathognomonic . . ." It is agreed, however,[2,3,9,14,24,26] that the roentgenologic examination is of tremendous importance, especially in the recognition of the early lesion, and it has been suggested by Hruby and Sweany that "perhaps no other one factor has been so important as the roentgenogram in contributing to the changing attitude toward carcinoma of the lung." The position of the roentgenologist was clearly defined by Kirklin in 1929 by the statement: "In short, although the roentgenologist will often be the first to discover signs of pulmonary carcinoma or vaguely suspect its presence, he can seldom make a positive diagnosis without clinical aid. On the other hand, the clinician will usually require the stimulus of the roentgenologist's report to orient his investigation and he will certainly need the help of the roentgenologist and the bronchoscopist in making the final diagnosis."

The present study has been undertaken to find out what may be learned from a review of the roentgenograms in a large series of cases (206) in which the diagnosis of primary carcinoma of the lung was established by histologic examination of tissue obtained on bronchoscopy (146 cases) or at necropsy (30 cases), or in which microscopic verification of the clinical and roentgenologic diagnosis was based on demonstration of metastatic carcinoma in the lymph nodes of the supraclavicular, cervical, or axillary regions (27 cases). Three cases in which the diagnosis was confirmed by histologic examination of a specimen from the lung obtained at operation were added, bringing the total to 206.

The fact that this study is based on a selected group of cases is emphasized for the reason that, in all probability, it represents only a portion of the total number of cases of primary carcinoma of the lung seen at The Mayo Clinic during the ten years from 1928 through 1937. The histories of about 1,000 patients, indexed under the diagnosis of carcinoma of the lung, both primary and secondary, were reviewed and only about 200 were selected for inclusion in the present series. In many instances there was ample clinical and roentgenologic evidence of primary bronchogenic carcinoma. But for the purpose of this study it has been assumed that conclusions regard-

* Abridgment of thesis submitted by Dr. Olds to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of M.S. in Radiology. Read at the Fortieth Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 19–22, 1939.

ing the roentgenologic diagnosis must be drawn from the findings in histologically proved instances of the disease.

The histologic characteristics of the tumors in this series have been noted and the carcinomas have been classified as squamous cell carcinoma, adenocarcinoma, and a combination of the two. The inclusion of a group of "undifferentiated cell" carcinomas has been avoided by classifying the tumors ordinarily placed in that category simply as adenocarcinomas, Grade 4. Simons has noted a growing tendency to substitute the simple for the more elaborate cellular classification of these tumors and such a plan seems most practicable for the purpose of this study. With the permission of Dr. A. C. Broders,[4] all tumors graded 3 and 4, according to his method, have been reported on the basis of the routine tissue examinations, the majority of which were made in his laboratory. The sections from all tumors graded 1 and 2 have been reviewed by Dr. Broders' associate, Dr. J. R. McDonald, who has also graded the tumors in the group of cases in which necropsy was performed.

Proper interpretation of the roentgenogram in diseases of the lung must necessarily be based on a clear conception of the pathologic changes which take place. Fried has shown that carcinoma which is primary in the lung has its origin in the basal cells of the bronchial epithelium and that alveolar carcinoma does not exist. This view is shared by numerous other investigators[2,3,10,20,40,47] with the understanding, in some instances, that alveolar carcinoma, if it does exist, is rare.

Most commonly, the tumors arise in the wall of a large bronchus near the point of division of the main bronchi, and spread to involve the adjacent hilar and mediastinal lymph nodes. Nodular growths, which project into the lumen of the bronchus, tend to produce early bronchial occlusion, whereas the flat type may spread in the submucosa without such alteration. Perforation of the bronchial wall with extension into the parenchyma of the lung may be followed by a rapid spread along the peribronchial lymphatic vessels,[42] or the tumor may surround the bronchus to produce stenosis by constriction from without.[8] More or less diffuse parenchymal involvement may follow, with subsequent necrosis and formation of pulmonary abscess. Occasionally, the growth may involve an entire lobe, producing an appearance similar to that seen in the gray hepatization of pneumonia.[35] Rarely, the carcinoma may arise in a small bronchus, well removed from the hilum and appear as a rounded, nodular or wedge-shaped infiltration in the parenchyma. Twining[42] observed that in these instances the hilar nodes are usually involved late, but as a rule there is a band of infiltration extending from such a growth to the hilum.

Local metastasis from pulmonary cancers proceeds by way of the lymphatic vessels and there is ample proof[35] of visceral and skeletal metastasis by way of the blood stream. The not infrequent occurrence of metastasis in the brain without clinical, and in some instances, without roentgenologic manifestations of pulmonary disease, is evidence of the insidious character of primary carcinoma of the lung.

On the basis of the pathologic changes thus briefly described, what shadows may we expect to find in the roentgenogram? In general, variations from the normal will be in proportion to the extent of the disease, but an example will be shown of a negative roentgenogram of the thorax of a patient who subsequently was proved to have had a bronchogenic carcinoma at the time the roentgenogram was made (Fig. 1).

A unilateral infiltration in the hilum is one of the earliest signs of the central or hilar type of primary bronchial malignancy[23,26] and according to Twining[42] is "the picture presented by more than fifty per cent of all cases when first seen." Although this shadow of increased density may be well circumscribed, it is more commonly diffuse with an indefinite blurred margin and is attributable, at least in part, to peribronchial extension of the growth.[22,42]

Bronchial obstruction, resulting from intrabronchial occlusion or extrabronchial constriction, gives rise to the next most common early sign of the central type which is atelectasis.[23,27,39] Atelectasis may be partial or complete, depending on the degree of stenosis and may involve a portion of a lobe, an entire lobe, or the whole lung, depending on the site of the obstructing tumor. Parenchymal extension of the tumor which follows infiltration and perforation of the bronchial wall may, as previously described, go on to necrosis and formation of abscess, or in some instances, lobar consolidation.[34] In the absence of secondary changes which may obscure them, these changes can be identified in the roentgenogram.

Tumors arising in intermediate and terminal bronchi, which may conveniently be called the peripheral type, produce shadows at some distance from the hilum and may or may not be recognized by the presence of atelectasis in the outer zone of the lung. This type may be associated with secondary pyogenic infection manifested by bronchiectasis and formation of abscess.[13] Both centrifugal and centripetal extension from these peripheral tumors have been observed.[34,42,46]

Recognition of the basic pathologic changes becomes more difficult with the appearance of secondary processes. As a rule, these processes are associated with advanced bronchogenic cancer in which it may be impossible to differentiate between the central and peripheral types.[24,35] These complications include pneumonia, pulmonary abscess, empyema, marked pleural thickening and less commonly, bronchiectasis, massive atelectasis, and pleural effusion.[2,20,23,34,35,38,39,40]

The incidence by age and sex of primary carcinoma of the lung in the group of 206 patients is substantially the same as that shown in the tables prepared by Simons. The disease was encountered most often in patients between the ages of fifty and fifty-

Fig. 1. Primary carcinoma of the right lower lobe bronchus in a man aged fifty-seven, whose only symptom was wheezing for one month and who had noted blood-streaked sputum on one occasion about one month prior to his registration at the Clinic. The day after this roentgenogram was made, bronchoscopic examination revealed a tumor in the right lower lobe bronchus and on biopsy the lesion was found to be adenocarcinoma, Grade 4. Excepting evidence of old tuberculosis in both apices, this roentgenogram and one made two months later were reported negative. A third examination one month later showed diminished aeration of the entire right lung and permitted a roentgenologic diagnosis of an obstructing lesion in the right main bronchus.

Table I

PRIMARY CARCINOMA OF THE LUNG: INCIDENCE BY AGE AND SEX, 206 CASES

Incidence				
By Age		By Sex		Total
Decade	Number	Men	Women	
3	7	162	44	206
4	21			
5	45			
6	77			
7	50			
8	5			
9	1			
Total	206			

TABLE II

PRIMARY CARCINOMA OF THE LUNG: TYPE OF TUMOR AND GRADE OF MALIGNANCY

Type of Carcinoma	Grade				Totals
	1	2	3	4	
Adenocarcinoma	8	8	33	62	111
Squamous cell			40	52	92
Mixed squamous and adenocarcinoma			2	1	3
Totals	8	8	75	115	206

nine years, and in men approximately four times as often as in women (Table 1).

The anatomic situation of the tumor was established by bronchoscopic examination or necropsy in 180 of the 206 cases in this series. The right lung was involved approximately twice as often as the left, and the lesion occurred with greatest frequency in the bronchus of the right lower lobe; 58 cases, or 33 per cent. Less frequently involved were the right main bronchus in 35 cases, the left main and left lower lobe bronchus in 26, and 24 cases, respectively, the right upper lobe bronchus in 17 cases, the left upper lobe bronchus in 9 cases, and the bronchus of the right middle lobe in 6 cases.

These figures are at variance with those of Simons, whose classification of 649 cases with respect to lobar involvement showed the upper lobes to be the site of predilection, with the left upper lobe involved somewhat more commonly than the right. Considering the lesions in the right middle lobe and the lower lobes on both sides, however, his figures show the right side to be the most frequent site of origin. It is interesting to note, however, that Vinson, in his review of 71 cases in which the diagnosis was made by bronchoscopic examination, found the lesion in the right lower lobe bronchus in 23 cases, or slightly more than 32 per cent. Next most commonly involved was the right main bronchus (21 cases), whereas lesions in the upper lobe bronchi on either side were present in only 5 cases. Westermark[46] in a series of 46 proved cases found the lesion most frequently in the bronchi of the lower lobes and a similar experience was reported by Ormerod.

Of the 206 tumors represented in the present series, 111 were adenocarcinomas, 92 were squamous cell carcinomas, and 3 were classified as mixed squamous cell carcinomas and adenocarcinomas. All the low grade carcinomas, 8 of which were graded 1* and 8 graded 2, were adenocarcinomas. All the squamous cell carcinomas and 95 of the adenocarcinomas were graded 3 or 4 (Table II).

The duration of symptoms before roentgenologic examination in 175 of this group of 206 patients would seem to indicate that almost all stages of the pathologic process have been observed. In 21 instances, symptoms had been present for four weeks or

TABLE III

PRIMARY CARCINOMA OF THE LUNG: DURATION OF SYMPTOMS BEFORE ROENTGEN EXAMINATION (175 PATIENTS)

Months	Patients
1	21
2	18
3	10
4	16
5	14
6	25
7	6
8	11
9	10
10	5
11	4
12	16
More than 12	19
Total	175

* In this group of 8 Grade 1 adenocarcinomas are included the tumors described by Peterson and others as "benign adenomata." Although none of the Grade 1 tumors in this series can be shown to have metastasized, it is Broders'[5] contention that they were malignant and should be recognized as such. In 5 of these 8 cases the roentgenologic changes were minimal, and were limited to signs of bronchial obstruction, but in 2 there was definite evidence of tumor mass at some distance from the hilum, and in one an absence of diaphragmatic excursion on the side of the lesion.

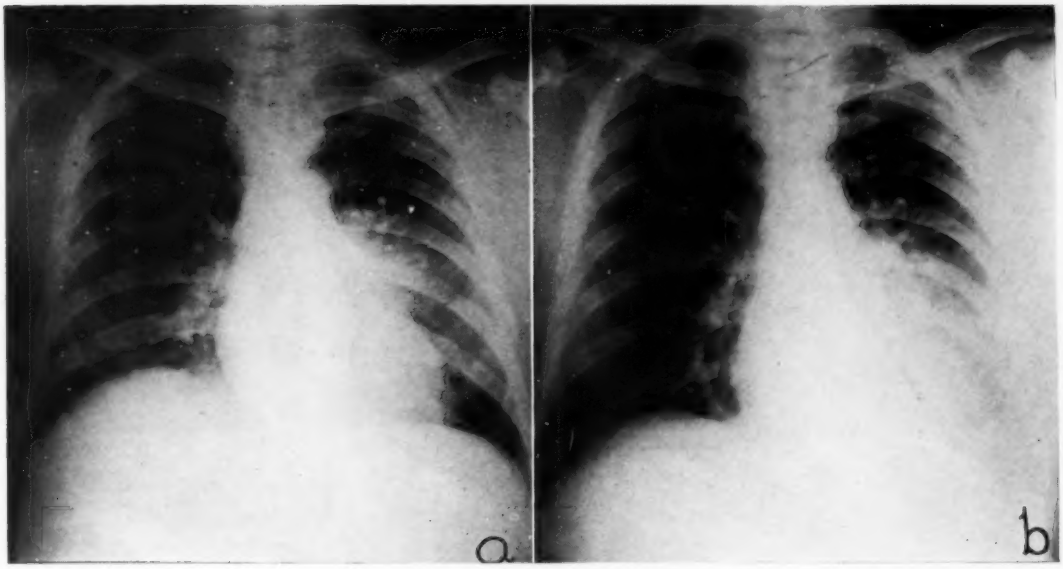

Fig. 2. *a*, primary carcinoma originating in the left main bronchus with roentgenographic changes limited to an increased density in the left hilum. The patient, a man aged fifty, had had pain in his chest and occasional hemoptysis for eight months. Bronchoscopic examination revealed an infiltration in the wall of the left main bronchus at its junction with the bronchus to the left upper lobe. There was no ulceration, and on biopsy the tissue showed only inflammatory changes; *b*, roentgenogram of the same patient nine months later showing increased density of the shadow in the left hilum and partial atelectasis of the left lower lobe. The patient's previous symptoms had persisted and he had lost weight. An ulcerating lesion obstructing the left lower lobe bronchus was found on bronchoscopy, and on biopsy the tumor proved to be a squamous cell carcinoma, Grade 3.

less, whereas in 19 they had been present for more than a year. The mean duration of symptoms for the entire group was about six months (Table III).

In considering the roentgenologic manifestations in these 206 proved cases of primary carcinoma of the lung, it should be kept in mind that 75 per cent of the roentgenograms were simply the routine stereoscopic, posteroanterior projections exposed at full inspiration at a target-to-film distance of 5 feet. Lateral views of the thorax were available in only 36 cases, and the report of a roentgenoscopic examination was available in only 16 cases.†

Interestingly enough, the roentgenologic changes which have been interpreted as atelectasis, and those classified as unilateral infiltration in the hilum (with or without extension into the parenchyma) were observed with equal frequency and represent the most significant changes in about two-thirds of the roentgenograms. Within this group (136 cases), approximately one-third presented atelectasis alone, one-third, hilar infiltration alone, and the remainder presented a combination of the two. Most writers are agreed that the presence of these changes demands further investigation to rule out or establish the presence of carcinoma.[17,26,35]

Hilar infiltration, that is, an abnormal increase in density in the region of the hilum on one side which is definitely not attributable to exaggeration of the vascular shadows, might be considered the most nearly pathognomonic of any of the roentgenologic changes associated with primary bronchial malignant neoplasm[23,26,38] (Fig.

† While anteroposterior projections using the Potter-Bucky diaphragm have long been employed for better definition of dense shadows seen in the routine roentgenograms of the thorax, lateral projections, requiring a relatively longer exposure and in which detail is usually obscured by motion of the heart, have heretofore been considered of little value. In recent months, however, this difficulty with respect to lateral projections has been overcome by making rapid exposures with a rotating anode tube and fast moving Potter-Bucky diaphragm.

2*a* and *b*). It will be recalled, however, that in this series such a change was no more commonly observed than was some degree of atelectasis. When this change was present, it was confined to the hilum proper in about one-quarter of the cases, involved the cardiophrenic angle in another one-quarter, and in the remainder there was definite extension of the shadow into the parenchyma of the lung.

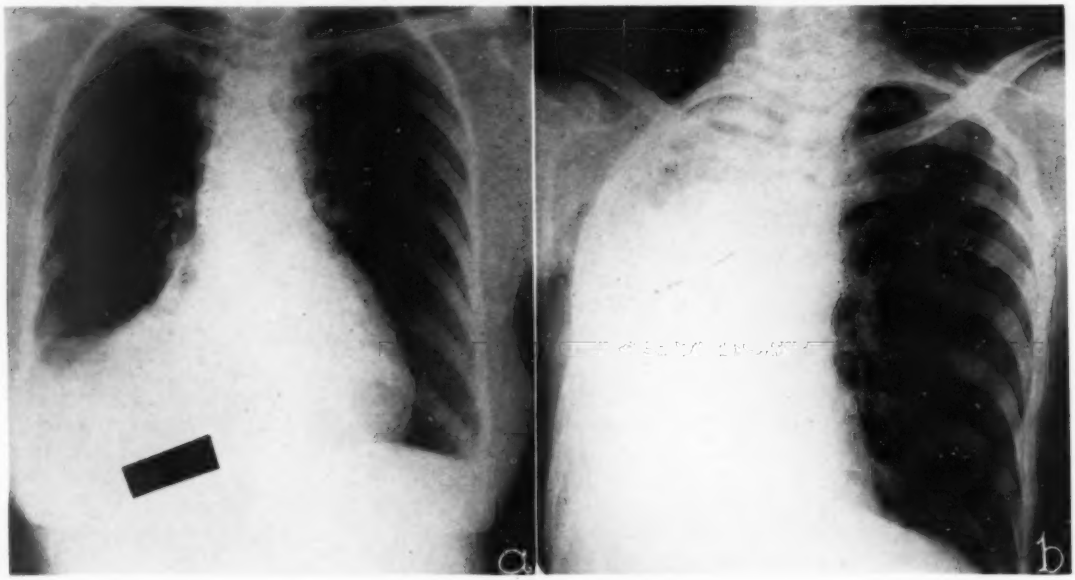

FIG. 3. *a*, primary carcinoma of the right lower lobe bronchus showing complete atelectasis of the right lower lobe. There is moderate compensatory emphysema of the right middle and upper lobes, flattening of the diaphragm on the left, and slight deviation of the trachea to the right. The heart is not displaced. The patient was a woman, aged fifty-five, who complained of a productive cough, weakness, and loss of weight. On bronchoscopy an ulcerating bleeding lesion, which proved to be a squamous cell carcinoma, Grade 4, was found, almost completely occluding the right lower lobe bronchus; *b*, primary carcinoma of the right main bronchus, producing massive atelectasis of the right lung. The patient, a man aged sixty-five, had suffered for two to three years with cough, dyspnea, and intermittent fever and more recently had been raising large quantities of sputum. An obstructing lesion of the right main bronchus was found on bronchoscopy, but multiple biopsies of the tumor showed only inflammatory changes. The patient died less than two months after registration at the Clinic and at necropsy was found to have a pedunculated tumor high in the right main bronchus and almost complete atelectasis of the right lung. The tumor proved to be a mucoid adenocarcinoma, Grade 2.

When atelectasis was present in one lobe or in an entire lung (98 cases), the incidence of partial and complete atelectasis was about equal (Fig. 3*a* and *b*). So-called massive atelectasis, with the classical signs of a homogeneous increase in density over an entire pulmonary field, a shift of the mediastinal structures toward the affected side, elevation of the diaphragm, and possibly some narrowing of the intercostal spaces on the involved side, was observed in 13 cases. Not uncommonly, the shadow of an atelectatic lobe or portion of a lobe is mistaken for that of the tumor. This confusion may be of little moment in a case in which the roentgenologic changes are minimal. But Graham[16,17] made the point that the size of the shadow is not necessarily in any way proportional to the size of the tumor. A tumor no larger than a pea may produce bronchial occlusion, which is followed, sooner or later, by the well-known phenomenon of atelectasis. Although the shadow of a tumor or the reactive process in its immediate vicinity is usually obscured by collapse of a portion of the lung, that which

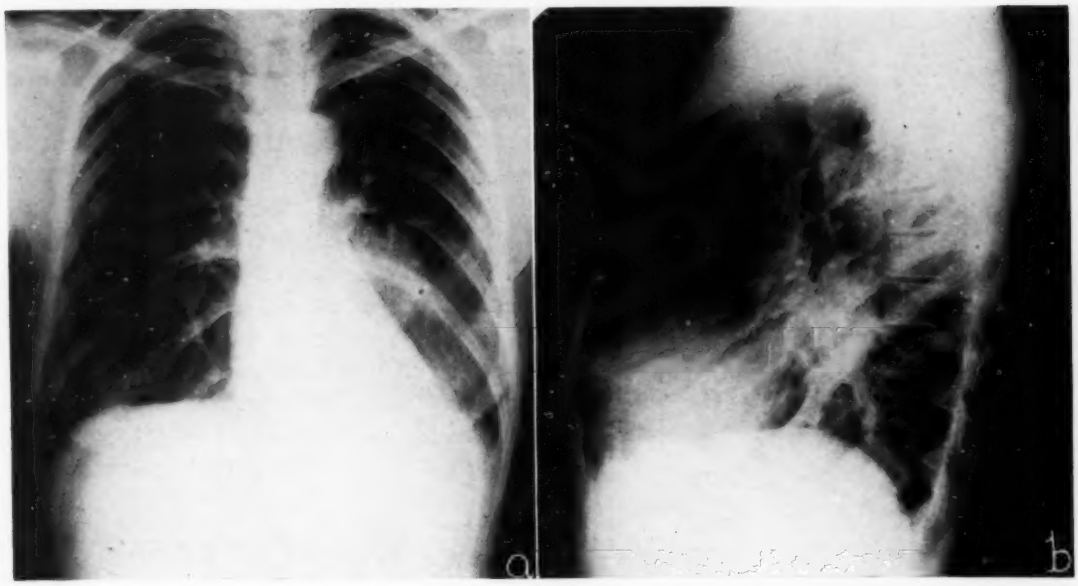

Fig. 4. *a*, primary carcinoma of the left main bronchus, producing a definite shadow of tumor in the left hilum and partial atelectasis of the left lower lobe. The patient was a woman, aged forty-six, who had complained of cough, dyspnea, and hemoptysis of only four months' duration. Bronchoscopy revealed definite stenosis of the left main bronchus just below the bifurcation of the upper lobe bronchus and a specimen removed from the bronchial wall at that point showed adenocarcinoma, Grade 3. The patient died shortly after total left pneumonectomy. Examination of the operative specimen revealed a tumor 5 cm. in diameter involving the left hilum and lower lobe of the left lung; *b*, lateral roentgenogram of the thorax of the same patient.

was interpreted as being a definite tumor was recognized in association with atelectasis in 13 instances in this series (Fig. 4*a* and *b*). In only 5 of the roentgenograms was a well-defined tumor seen through the shadow of hilar infiltration.

An elaborate classification of primary carcinoma of the lung, either pathologic or roentgenologic, has been avoided intentionally. In discussing the macroscopic characters of these cancers, Simons concludes that "any classification based on gross characteristics is likely to be more applicable to stages of tumor growth than to distinct types." Recognizing that the complications present in the majority of cases produce a great diversity of roentgenologic changes, Christie favored a grouping that is broad and general. Accordingly, he recognized two main types, the hilar and the parenchymal, and this simplified classification is supported, at least in principle by numerous contemporary writers.[18,22,23,31,35,40] Christie preferred the term "hilar" to "bronchial" in Kirklin and Paterson's[21,22] classification, "since the latter term, applied to the main trunk tumors implies that the peripheral tumors are not bronchial in origin." In this connection, it should be emphasized that the terms "peripheral" or "parenchymal" refer only to the situation of the tumor and are not descriptive of its histologic character.[24]

The roentgenologic changes described thus far have been characteristic of the hilar type. Parenchymal or peripheral tumors were uncommon in this group of 206 patients, accounting for about 7 per cent of the total, but this figure is of little significance if one considers the basis on which these cases were selected. Characteristically, the peripheral tumors were represented by a rounded shadow of increased density, not sharply demarcated from the surrounding portion of the lung (Fig. 5). The hazy margin may serve to differentiate between a

FIG. 5. Primary carcinoma of the lung manifested as a rounded shadow of increased density away from the hilum and not sharply demarcated from the surrounding pulmonary parenchyma. There is a small amount of fluid at the base of the right lung. The patient was a man, aged forty, who had had cough, weakness, and some loss in weight over a period of about nine months. Two bronchoscopic examinations showed only stenosis and infiltration of the right upper lobe bronchus and biopsies showed only inflammatory changes. An exploratory thoracotomy revealed an inoperable carcinoma of the right lung with secondary infection, and histologic examination showed this to be a squamous cell carcinoma, Grade 4.

primary and a metastatic tumor, but it should be noted that Twining[42] has observed "many examples of [primary] nodular carcinomata of the lung parenchyma retaining their sharply defined contours. . . . " even when they have attained considerable size. The fact that the peripheral type of primary tumor is almost invariably single, whereas secondary nodular tumors usually are multiple, is a better criterion for their differentiation.

A third roentgenologic type of primary carcinoma of the lung is that originally described by Pancoast in 1932 as a tumor of the "superior pulmonary sulcus" associated with a characteristic clinical syndrome. At first believed to be independent in its origin of lung, pleura, ribs, or mediastinum, it is now the consensus[8,15,36,37] that this tumor is a bronchogenic carcinoma arising in the region of the pulmonary apex and that various other apical tumors may produce the same clinical picture. One case is included in this series (Fig. 6).

The several complications which tend to obscure the underlying pathologic changes and make more difficult the roentgenologic diagnosis of primary carcinoma of the lung have been described. In this series of 206 proved cases, evidence of fluid was observed in 33 cases, but of that group only 11 cases (about 0.5 per cent of the total)

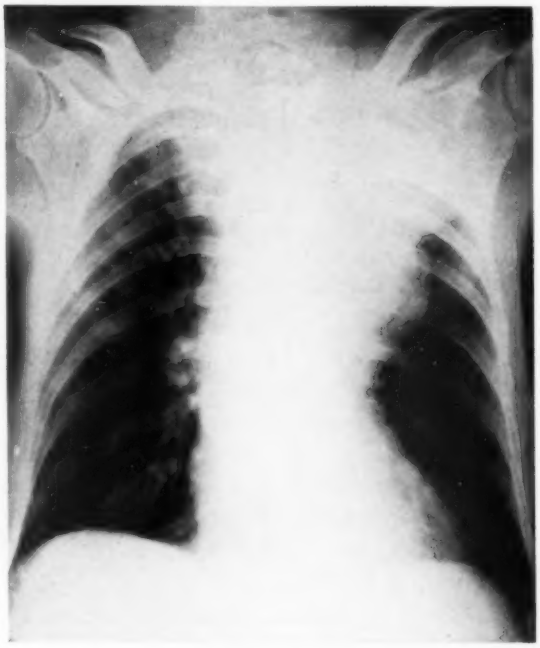

FIG. 6. Primary carcinoma of the lung involving the entire upper lobe of the left lung (Pancoast's tumor). The patient was a woman, aged sixty-four, who had pain in the left shoulder and who had lost considerable weight over a period of six months. Notable among the physical findings was the presence of Horner's syndrome on the left. The patient died four months after registration at the Clinic and at necropsy was found to have had a tumor 17×17×15 cm. which replaced the upper lobe of the left lung. There were extensive metastases with invasion of the left subclavian vein and brachial plexus. Histologic examination showed the tumor to be a squamous cell carcinoma, Grade 4.

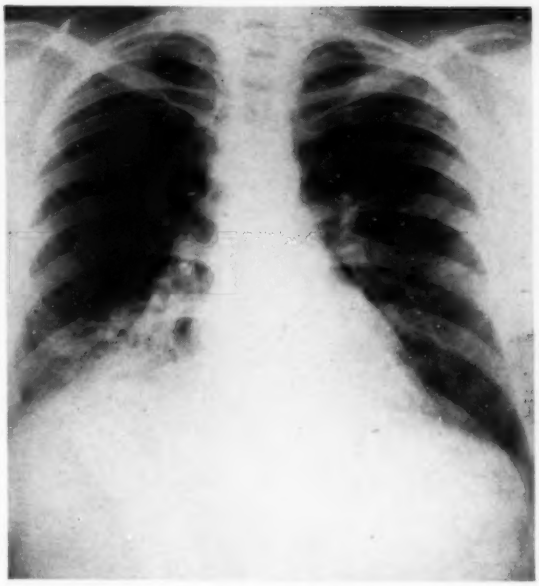

Fig. 7. Primary carcinoma of the right lower lobe bronchus with roentgenographic changes limited to those of diffuse bronchiectasis at the base of the right lung. The patient was a man, aged thirty, who had had numerous episodes of cough with expectoration, fever and pleuritic pain in the lower portion of the right side of the thorax. Bronchoscopic examination on the day this roentgenogram was made disclosed the presence of a tumor in the right lower lobe bronchus, impressing the secondary bronchi, but the biopsy showed only inflammatory changes. Biopsies made ten and eleven months later also showed inflammatory changes, but on the fourth examination (one year from the date of registration) the tumor was found to be an adenocarcinoma, Grade 4.

presented a picture of complete hydrothorax. Changes interpreted as bronchiectasis were noted in 15 cases and definite evidence of pulmonary abscess in 7 cases (Figs. 7 and 8*a* and *b*). A homogeneous dense shadow obscuring a considerable portion of the pulmonary field and characteristic of no one pathologic entity was confusing in 15 cases. Lobar infiltration, more or less suggestive of pneumonia, was present in 8 cases and bilateral mediastinal widening, not inconsistent with the changes of lymphoblastoma, was observed in 6 cases.

As incidental findings, evidence of metas-

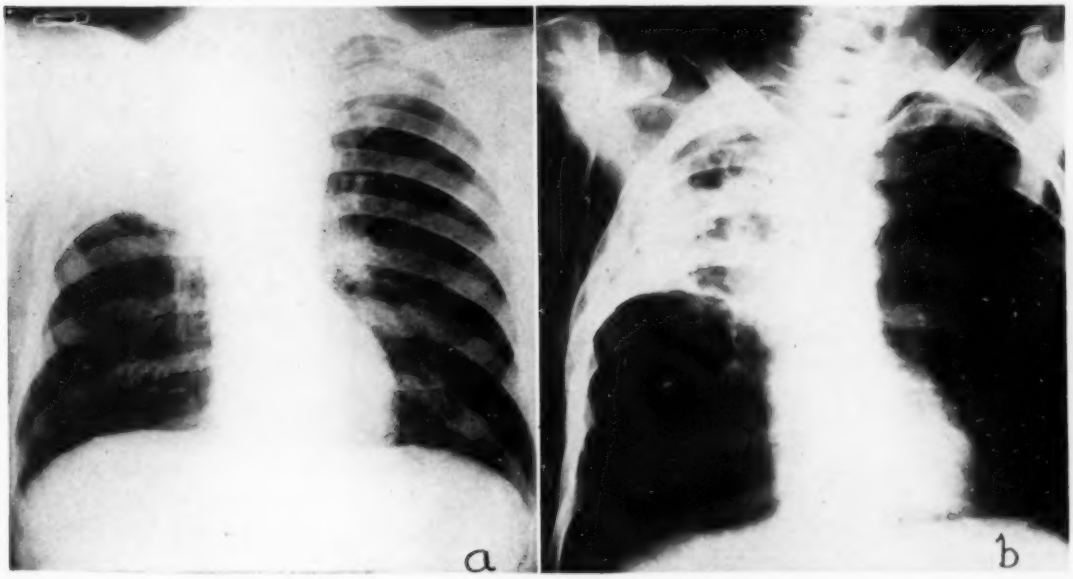

Fig. 8. *a*, routine thoracic roentgenogram, and *b*, roentgenogram made with a Potter-Bucky diaphragm. Primary carcinoma of the right upper lobe bronchus. The roentgenographic changes are those of a large, multilocular abscess confined to the upper lobe of the right lung. The patient, a man aged fifty-one, complained of pain in the right side of the thorax, dyspnea and weakness, and had lost 70 pounds (32 kg.) over a period of fifteen months. Bronchoscopic examination showed a large, infiltrating growth projecting into the right main bronchus from the right upper lobe bronchus. Biopsy showed squamous cell carcinoma, Grade 4.

FIG. 9. Primary carcinoma of the left upper lobe bronchus, showing partial atelectasis of the left upper lobe, but strongly suggesting pulmonary tuberculosis. There is slight displacement of the heart to the left. The patient was a woman, aged forty-three, who complained of loss in weight and pain in the upper portion of the left side of her chest of two months' duration. Bronchoscopy showed almost complete obstruction of the left main bronchus by a tumor mass from the left upper lobe bronchus and tissue removed from this lesion showed adenocarcinoma, Grade 2. Total left pneumonectomy was performed without incident and the patient was known to be living and well in September, 1938, one year following her operation. Note: Examination of the operative specimen revealed neither gross nor microscopic evidence of tuberculosis.

tasis to the opposite lung was noted in 2 cases, metastasis involving a rib in 1 case, and in another, metastasis in the dorsal spine. Marked elevation of the diaphragm on one side, suggestive of paralysis, was observed in 9 cases, and in 1 instance the primary tumor of the lung was associated with eventration of the diaphragm on the same side.

In order of their importance with respect to this series of 206 proved cases, the following conditions, of nonmalignant origin, most often had to be considered in the differential diagnosis of primary carcinoma of the lung: (1) bronchiectasis, (2) hydrothorax, (3) pneumonia, (4) pulmonary abscess, (5) lymphoblastoma, (6) pneumoconiosis of an advanced type, (7) pulmonary tuberculosis, and (8) aortic aneurysm (Fig. 9). In the presence of a single peripheral nodule, the possible existence of a metastatic malignant lesion also has had to be considered. To this list might be added a few of the less common lesions which are mentioned by other writers.[6,7,22] These include gumma, hydatid cyst, intrathoracic goiter, dermoid cyst, thymic tumor and neurofibroma.

For the purpose of this discussion it is sufficient simply to mention these conditions rather than to attempt a description of their roentgenologic characteristics. Pulmonary abscess, however, deserves special consideration. Manges and Farrell have noted that when an abscess is associated with displacement phenomena (of atelectasis), neoplastic origin of the abscess should be suspected. This observation was confirmed by Ormerod who pointed out that in the presence of pulmonary abscess of nonmalignant origin there is a relative increase in pressure on the involved side and the mediastinal structures either maintain their central position or shift slightly toward the normal side. Camp observed that in the case of primary malignant neoplasm with cavitation, the wall of the abscess is thicker and more irregular than that noted in an inflammatory lesion with cavitation. This latter criterion may have increased application in the tomographic study of pulmonary abscess.

Unrelated to this particular series of cases but of considerable importance with respect to the early diagnosis of primary carcinoma of the lung is the work of Westermark[44,45,46] who made an exhaustive study of bronchostenosis and atelectasis. He showed that, from the roentgenologic point of view, bronchostenosis can be divided into three stages. These he described with respect to the degree of stenosis and the corresponding changes in that portion of the lung supplied by the involved bronchus. In cases of slight stenosis he found

only slight opacity, caused by a diminished content of air and hyperemia. In the presence of more pronounced stenosis, he noted a wedge-shaped region of rarefaction caused by emphysema and anemia, and surrounding this, a zone of increased density caused by compression and atelectasis. Between stages 1 and 2 he recognized a transitional stage in which an inspiratory density and an expiratory rarefaction may be observed. In the third stage, or complete occlusion, the well-known changes of massive atelectasis were noted. Such precise analysis of the several stages of atelectasis and the recognition of its earliest signs are based on roentgenoscopic and multiple roentgenographic examinations made on expiration as well as on inspiration. The importance of this latter method has been mentioned by Clerf, who found it of great value in the recognition of nonopaque foreign bodies and suggested its application in suspected cases of carcinoma of the lung.

The fact that no such studies have been made on the patients included in the present series precludes further discussion of the value of the method. Likewise, no experience with bronchography in the diagnosis of obstructing lesions of the bronchi can be reported. It is recognized, however, that the use of iodized oil as described by Fariñas,[11,12] Rigler,[32,33] and others plays an important part in the diagnosis and localization of bronchogenic carcinoma in patients for whom bronchoscopy is impractical.

A third method of investigation, and one which seems to be particularly well adapted to the delineation of obstructing lesions of the bronchi, is tomography. Since none of the patients in the present series was examined with the tomograph, a special case

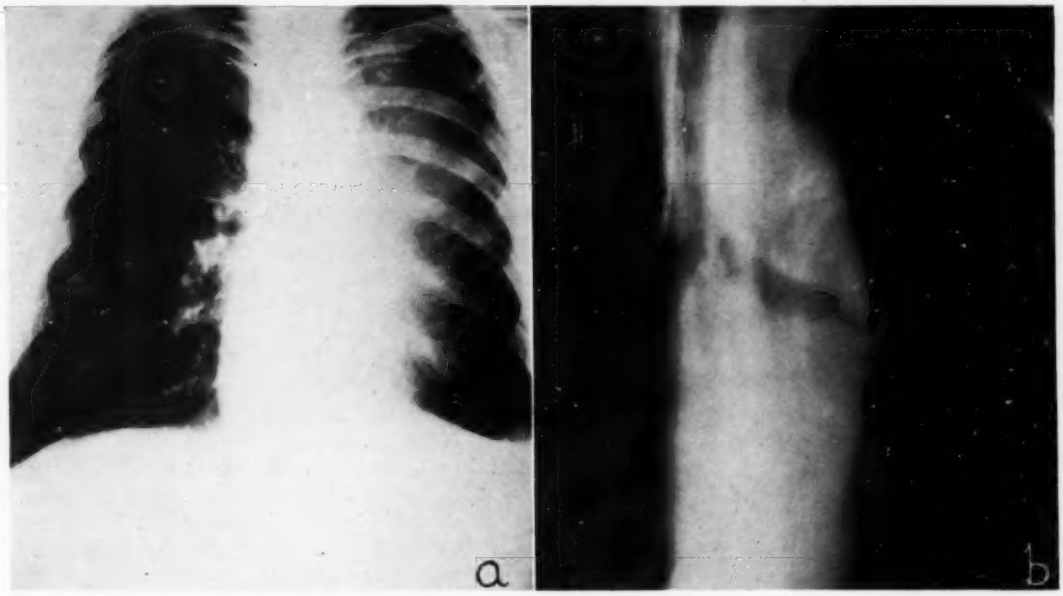

FIG. 10. *a*, roentgenogram showing a diffuse shadow in the left hilum and partial atelectasis of the upper lobe of the left lung. The patient, a man aged fifty-nine, had had dull pain in the anterior portion of the left side of the thorax, cough, and weakness, and had lost 37 pounds (17 kg.) in the eighteen months previous to his coming to the Clinic. Bronchoscopic examination was difficult because the left main bronchus came off at approximately a right angle to the trachea. Infiltration was observed at the level of the left upper lobe bronchus and a small amount of tissue appeared to project downward from the lateral wall. Although the biopsy showed only inflammatory changes, the patient was considered to have primary carcinoma of the left main bronchus and is receiving roentgen therapy at the time of writing; *b*, tomogram of the same patient, showing the tumor projecting downward from the lateral wall of the left main bronchus at the level of the bronchus to the left upper lobe.

has been added. The tomogram here reproduced (Fig. 10), was made with an apparatus attached to an ordinary Potter-Bucky table in the manner suggested by Twining.[41] It is offered as an illustration of the possibilities of tomography, which procedure may be used to supplement the usual exposures made with the Potter-Bucky diaphragm in both anteroposterior and lateral projections.

But the stated purpose of this study has been to review the routine roentgenograms in a large group of proved cases of primary carcinoma of the lung and, broadly, to evaluate the method as applied to this particular series. It has been shown that the most nearly pathognomonic of the roentgenologic changes is a unilateral increase in density in the hilum and that some degree of atelectasis is of scarcely less importance. One or both of these changes were observed in two-thirds of the cases studied, and in retrospect, it is clear that their presence should suggest at once the possible existence of bronchial malignancy. Likewise, the presence of an ill-defined or rounded shadow of increased density, away from the region of the hilum, should be considered indicative of malignancy until proved otherwise.

Not infrequently, the earliest roentgenologic changes associated with bronchogenic carcinoma are those which may readily be confused with a benign inflammatory process. In a few such instances, the demonstration of displacement phenomena in the presence of abscess or bronchiectasis, the coexistence of atelectasis and hydrothorax, or the recognition of an elevated and immobile diaphragm on one side, may suggest the presence of malignancy. More often, however, the diagnosis of carcinoma will be considered only if its possibility is kept in mind.

It has been found that the roentgenologist was able to make a definite diagnosis of bronchogenic carcinoma or at least to suggest its presence in about 60 per cent of these 206 cases. In the remaining 40 per cent of cases, the condition in one-third was confounded with inflammatory lesions of the thorax; in one-third a merely descriptive report was made, and in the remainder the lesion was variously diagnosed as lymphoblastoma, metastatic carcinoma, interlobar fluid, tuberculosis, aneurysm, or "negative chest."

Whether the accuracy of diagnosis in this series could have been improved on remains an open question, but it is evident that carcinoma of the lung is sufficiently common to justify its more frequent consideration in the differential diagnosis in cases in which the cause of the pulmonary process is obscure.*

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* For discussion see page 383.

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RECENT PROGRESS IN THE BRONCHOGRAPHIC EXAMINATION OF BRONCHOGENIC CARCINOMA*

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IF WE expect to improve results in the treatment of primary carcinoma of the lung, it is necessary to know, in each case, the type of bronchial tumor and the location and extension of the neoplastic process in the bronchial wall.

By serial bronchography under roentgenoscopic control, such as we recommended in 1933, we are able to determine if the bronchial tumor is polypoid or infiltrating, and its extension in the bronchial wall, which cannot be demonstrated by any other method.

We have described the technique of serial bronchography in various papers and now we wish only to point out some modifications which we have introduced lately. It is well known that a good anesthesia of the bronchial tree is indispensable in bronchography but, since we know that almost all the accidents that have occurred are due to it, we are now using the least amount possible. At present we are using pantocaine, 0.5 per cent, and after it has been instilled into the bronchus we wait a sufficient length of time to obtain the best effect.

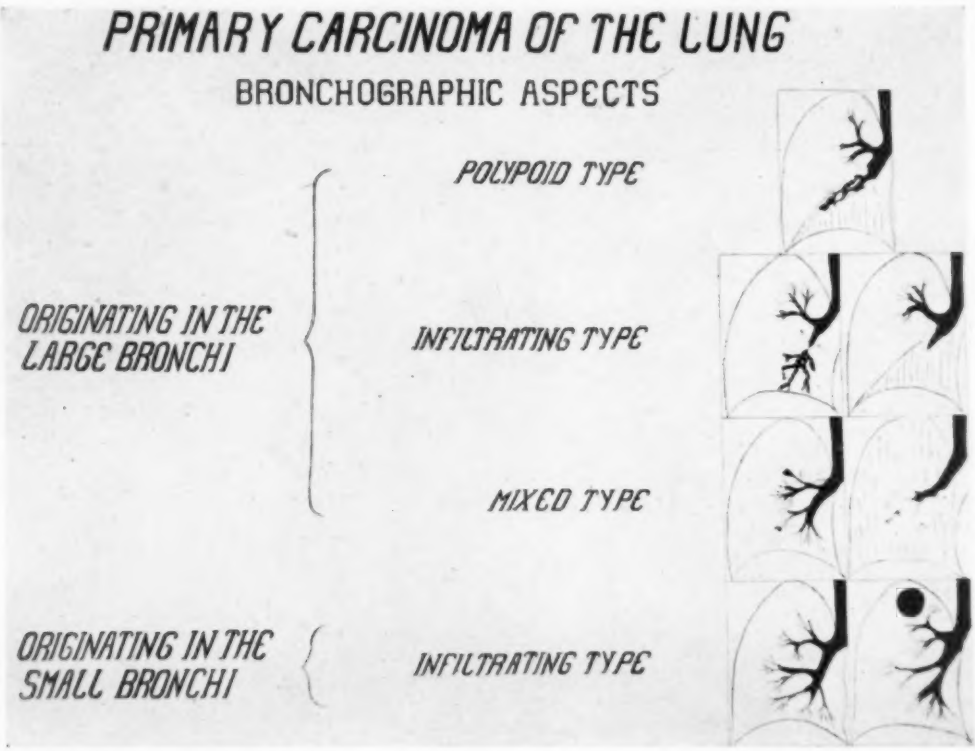


FIG. 1

Previous instruction to the patient regarding the various points of the examination is essential in order to gain his confidence and cooperation, without which the

* This work has been done in the Cancer Institute, in collaboration with Drs. Llambes, Banet, Sutter, and Luís Fariñas, in the clinical, surgical, pathological, and radiological aspects. Read at the Fortieth Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 19–22, 1939.

examination would prove to be very difficult.

During the past year we have substituted iodized oil in the bronchographic study of bronchogenic carcinoma with solutions of organic salts of iodine, such as uroselectan.

The iodized oil has many disadvantages. By its long standing in the lung parenchyma, especially in cases of incomplete stenosis of the bronchus, it causes well-known disturbances. The iodized oil thus retained, in patients receiving deep therapy, gives origin to a secondary radiation which materially burns the broncho-alveolar epithelium.

Another inconvenience of the iodized oil is that, when the bronchial stenosis is almost complete, it may not pass, due to its viscosity, and therefore may not show the extension of the neoplastic process in the bronchial wall.

The solutions of organic salts of iodine are not toxic or irritating; they are rapidly absorbed by the broncho-alveolar mucosa, and pass easily through even the narrowest stenosis. These opaque liquid media pass rapidly through the bronchial lumen and for that reason it is necessary to take the films while they are being injected. The rapid change from roentgenoscopy to roentgenography is essential, as are also the very short exposures.

With these technical details, and using uroselectan as the opaque medium, we have recently made a series of bronchographic examinations in which the study was done as nearly as possible before surgical intervention or necropsy, with a view to establishing precise comparisons between the bronchographic image and the anatomical specimen. We are able to demonstrate that there exists a practical correspondence between the two observations.

In order to study the bronchographic aspects of bronchogenic carcinoma we have adopted the classification shown in Figure 1.

The polypoid types are most frequently found in the large bronchi near the bifurcation of the trachea, but at times they begin at the entrance of a lobar bronchus. They appear as a vegetating tumor, round or irregular, that occludes more or less the lumen of the bronchus, and sometimes they occupy the bronchial wall to a great extent. At the base of the implantation of the tumor the bronchial wall is infiltrated.

The bronchographic aspect of the tumor is characteristic. It gives origin to a filling

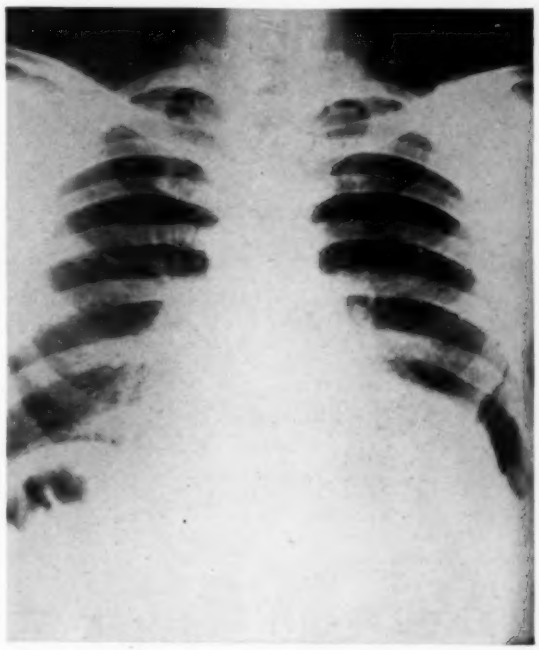


Fig. 2. Case 1.

defect in the bronchial lumen caused by the tumor displacing the opaque medium. The filling defect may be round or irregular, with frayed borders due to the malignant infiltration. This aspect permits us to differentiate polypoid carcinoma from the simple benign polyp, in which the borders of the filling defect are regular.

The filling defect determined by the polypoid carcinoma may appear in both borders of the bronchial shadow, or as an upper convexity obstructing almost totally the lumen of the bronchus.

Below the filling defect the bronchus is always dilated, and in this portion we observe round and irregular filling defects caused by the retained bronchial secretions displacing the opaque medium.

FIG. 3. Case 1.

FIG. 4. Case 1.

As an example of this type of lesion we present the following case:

CASE 1. M. R., aged thirty-nine. Bloody expectoration, fever, loss of weight. The roentgenogram shows complete atelectasis of the lower right lobe (Fig. 2).

Bronchoscopy. At 4 cm. of the tracheal bifurcation a polypoid tumor of the main right bronchus was observed obstructing its lumen completely.

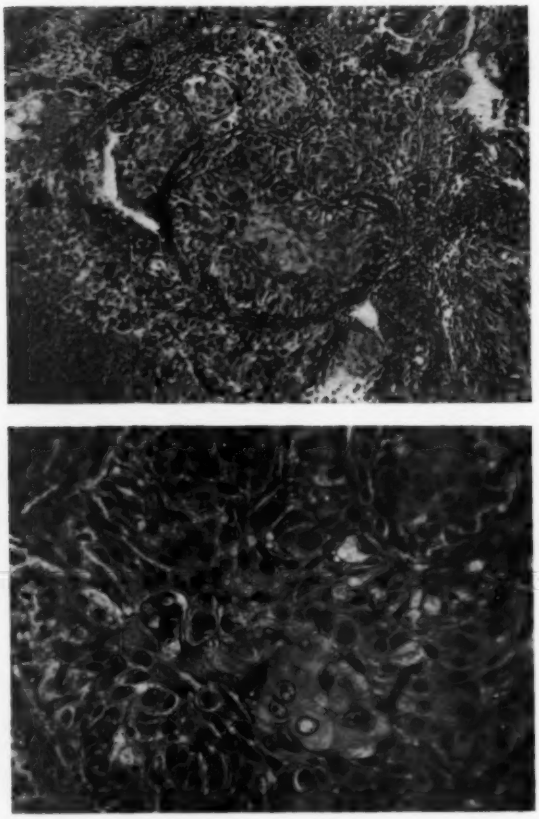


FIG. 5. Case 1.

Bronchography. Filling defect by a polypoid tumor of the main right bronchus with dilatation of the bronchi below (Fig. 3).

Patient had a pneumectomy. The specimen shows a large polypoid tumor starting at 4 cm. of the tracheal bifurcation extending along the whole bronchus of the middle lobe (Fig. 4).

Biopsy showed epidermoid epithelioma (Fig. 5).

The infiltrating forms are characterized by the neoplastic invasion of the mucosa and submucosa of the bronchus to a vari-

able extent. Provided the infiltrating lesion takes place in all the circumference of the bronchial mucosa, there is produced a concentric narrowing of the lumen of the bronchus, which is at times very extensive, taking up the main bronchus and its first branches.

In the infiltrating forms we have separated, for purposes of study, those that are

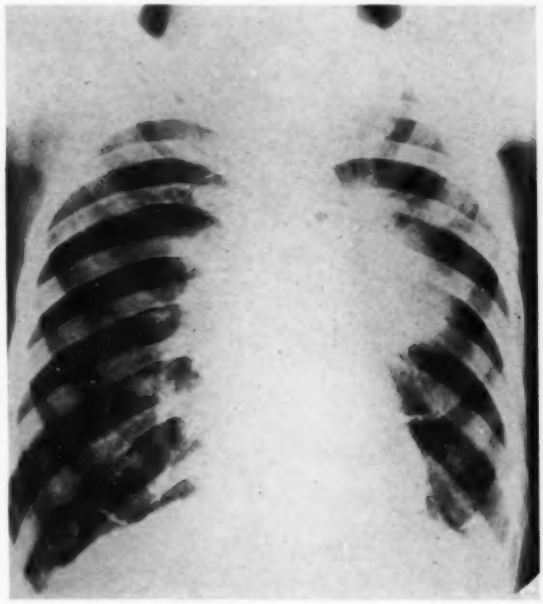


Fig. 6. Case II.

situated in the large and lobar bronchi, those of the third and fourth order bronchi, and those that are situated in the small bronchioles.

In the large bronchi, when the process is not so far advanced, we observe a concentric narrowing of the lumen of the bronchus with irregular borders.

Case II. V. B., aged sixty-two. Cough, bloody expectoration, loss of weight and pain in the right side of chest.

The roentgenogram shows an infiltrating type of hilar carcinoma (Fig. 6).

Bronchoscopy. Ulcerated infiltration of the left main bronchus.

The bronchogram shows an incomplete stenosis of the infiltrating type of the main left bronchus starting immediately below the bronchus of the upper lobe (Fig. 7). The film

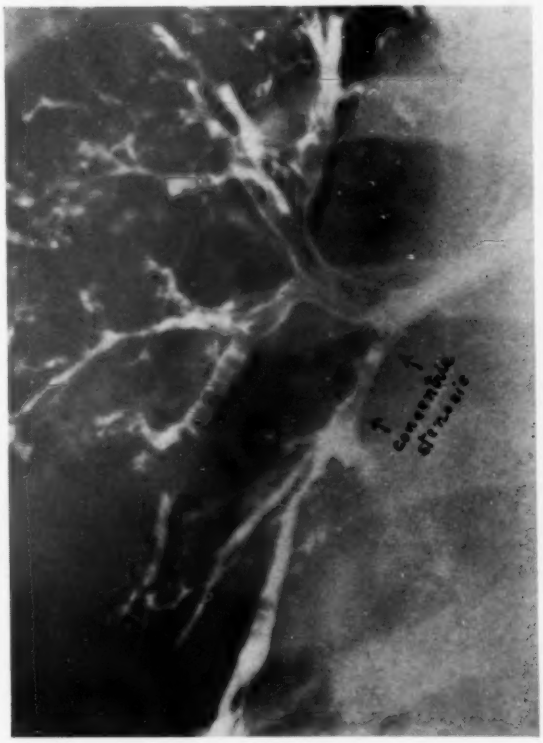


Fig. 7. Case II.

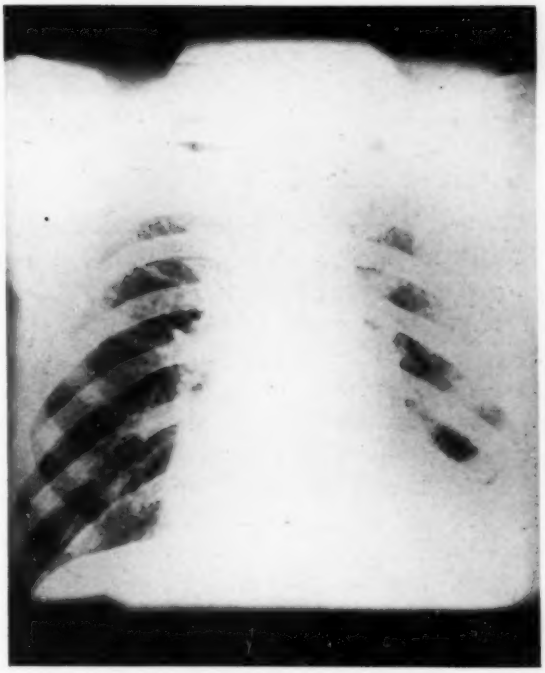


Fig. 8. Case III.

FIG. 9. Case III.

taken two months later showed pulmonary metastasis.

Biopsy showed undifferentiated carcinoma.

When the process is advanced, the lumen of the main bronchus is completely occluded, giving the bronchogram the aspect of an opaque cone, which was the only bronchographic sign of bronchial cancer before we described, in 1933, the bronchographic signs of the beginning of bronchogenic carcinoma. The pulmonary zone supplied by the obstructed bronchus presents all the roentgenographic characters of complete atelectasis.

CASE III. A. B., aged forty-five. Pain at the right base, loss of weight.

The roentgenogram shows a tumor at the right hilum and atelectasis of the right lower lobe (Fig. 8).

Bronchoscopy. Infiltrating stenosis of the main right bronchus.

Bronchography. Complete obstruction of the main right bronchus, "opaque cone" (Fig. 9).

The patient had a pneumectomy. The specimen shows an infiltration with complete stenosis of the main right bronchus and peribronchial infiltration. Atelectasis of the lower lobe (Fig. 10).

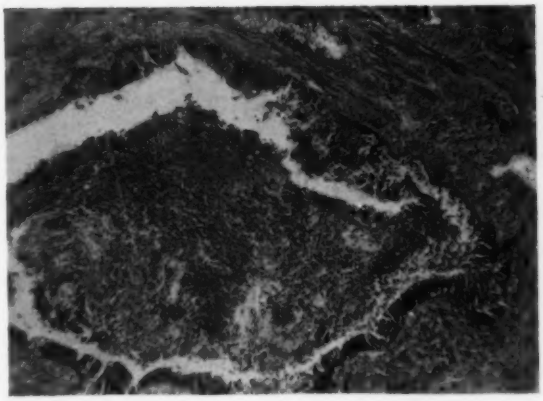
Biopsy shows epithelioma with small undifferentiated cells (Fig. 11).

When the neoplastic process is situated in the bronchi of the third or fourth order, we also observe the concentric narrowing or the complete obstruction described in the foregoing paragraphs, but as the lumen of the bronchus is very small the complete obstructions predominate, due to the fact that the lumen of the bronchus occludes itself more rapidly by the process.

CASE IV. M. R., aged thirty-four. No pulmonary symptoms.

The roentgenogram shows a nodular tumor at the upper left lobe (Fig. 12).

FIG. 10. Case III.



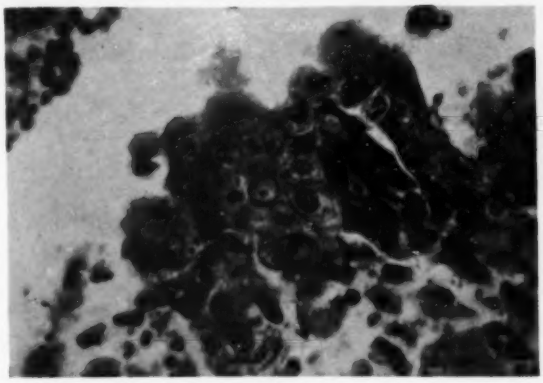


Fig. 11. Case III.

Fig. 13. Case IV.

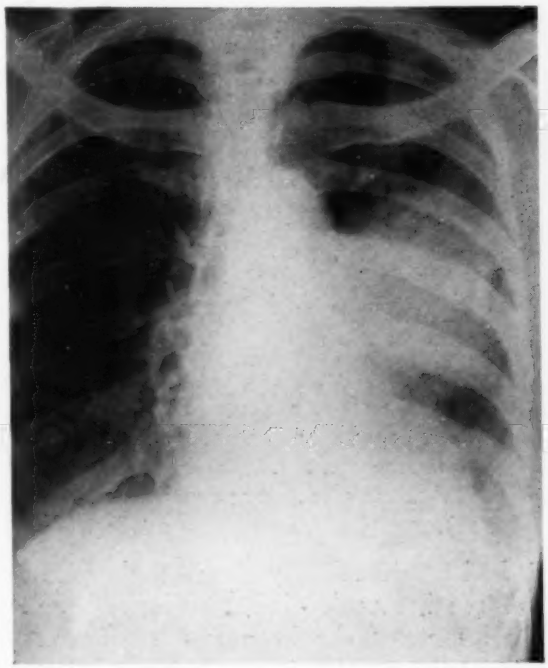


Fig. 12. Case IV.

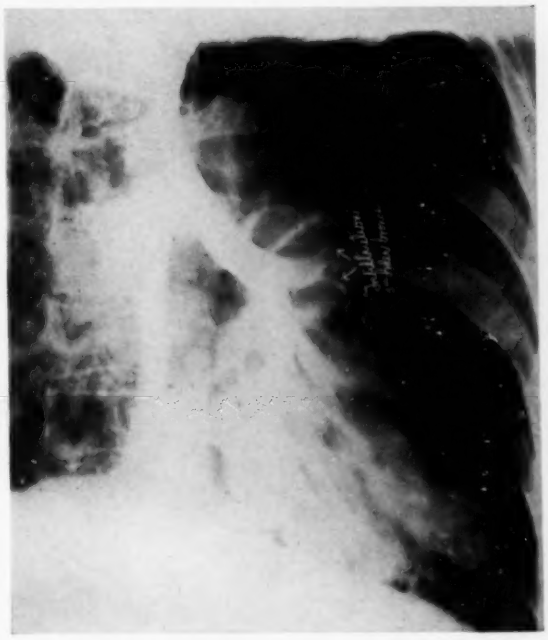


Fig. 14. Case IV.

FIG. 15. Case IV.

FIG. 16. Case IV.

In the tomogram the contour is clearly visible (Fig. 13).

Bronchoscopy. No bronchial alterations.

Bronchography. Main left bronchus and upper lobe bronchus normal, stenosis by infiltration of the third order bronchi of the upper lobe (Fig. 14).

Pneumothorax. The tumor appears lowered by the collapse of the upper lobe (Fig. 15).

Patient had a lobectomy. The upper lobe

FIG. 17. Case IV.

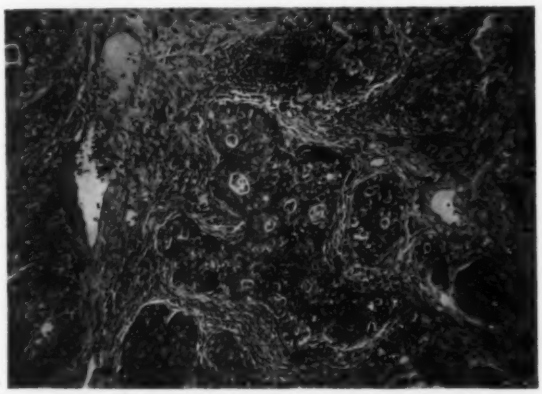
specimen shows the incomplete stenosis by infiltration of the apical and anterior branches of the upper lobe bronchus (Fig. 16). The open specimen shows the infiltration of the anterior apical and posterior branches of the upper lobe bronchus (Fig. 17).

Biopsy shows glandular atypical epithelioma (Fig. 18).

In bronchi of very small caliber we do not see incomplete obstructions, because the lumen of the bronchus is obstructed very rapidly and the bronchographic image is that of complete obstruction. At times,

the small bronchus, in which the infiltration started, is separated from the rest of the bronchial tree by the tumor that grows around it, which rejects the neighboring broncho-alveolar apparatus.

Case v. C. G., aged forty-five. Pain in the right side of chest, bloody expectoration. The



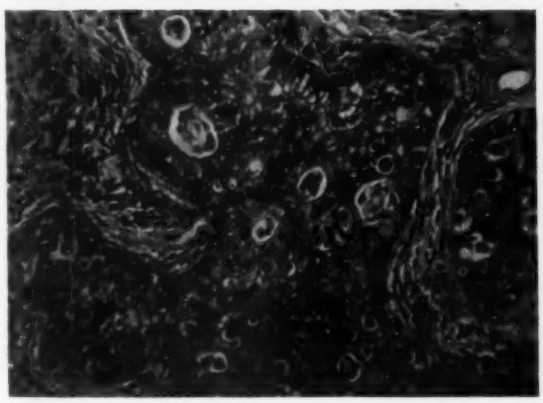


Fig. 18. Case iv.

roentgenogram shows a nodular type of tumor at the right upper lobe (Fig. 19). The bronchogram shows the compression and displacement of the bronchial tree by the tumor (Fig. 20).

The patient has had a lobectomy, and the large bronchial tree was found free from infiltration (Fig. 21).

Biopsy shows glandular epithelioma (Fig. 22).

In the mixed forms, when it appears in the large bronchi or in a lobar bronchus, a polypoid tumor is observed and infiltration of the bronchus that follows. We present Case vi, an early one, and Case vii, advanced.

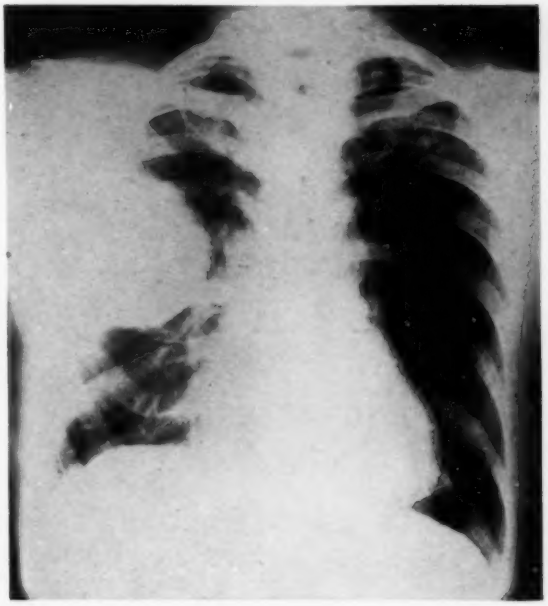


Fig. 19. Case v.

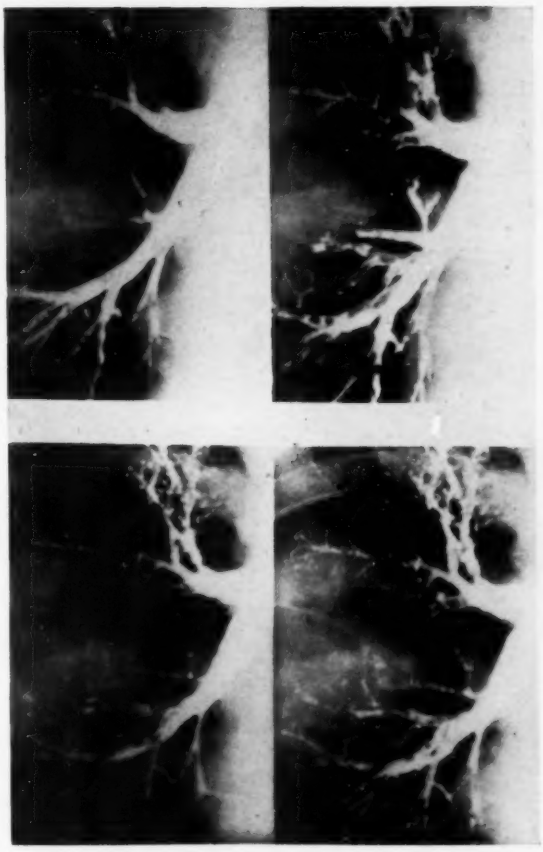
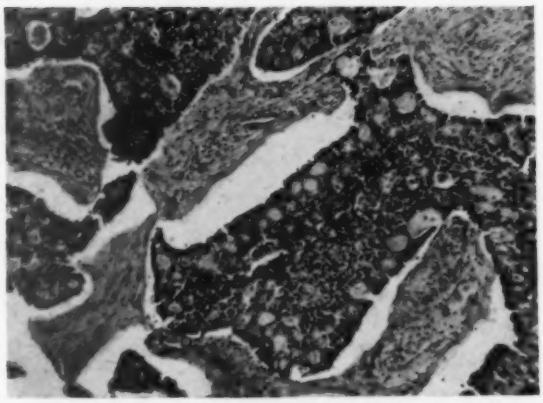


Fig. 20. Case v.

FIG. 21. Case V.



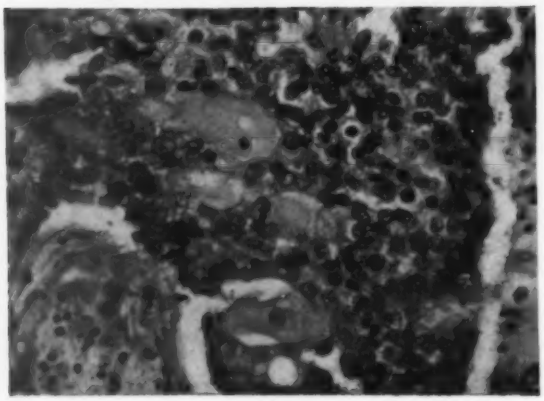


FIG. 22. Case V.

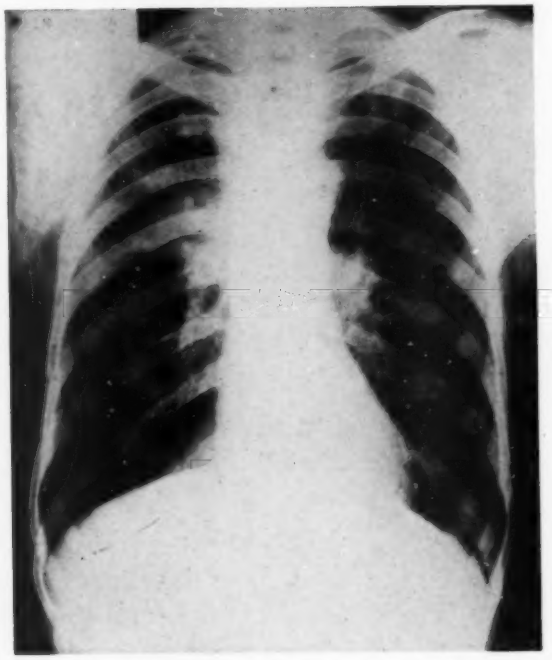


FIG. 23. Case VI.

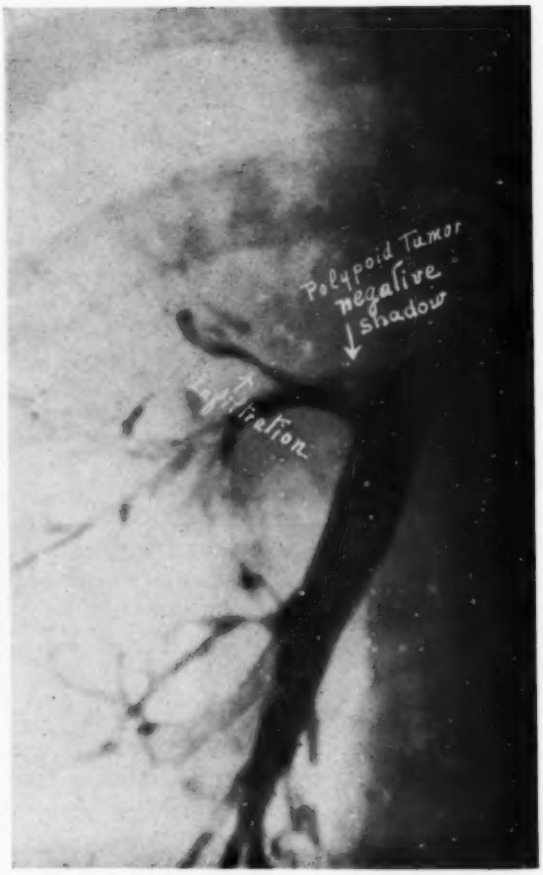


FIG. 24. Case VI.

Case vi. F. V., aged sixty-two. Cough, bloody expectoration, pain in the right side of chest and loss of weight.

The roentgenogram shows an infiltrating type of tumor at the upper part of the right hilum (Fig. 23).

Bronchoscopy. Polypoid tumor at the entrance of the upper right of the upper right lobe.

Bronchography. Filling defect produced by polypoid tumor at the entrance of the upper lobe bronchus and an incomplete stenosis by infiltration of the apical branch of this bronchus (Fig. 24).

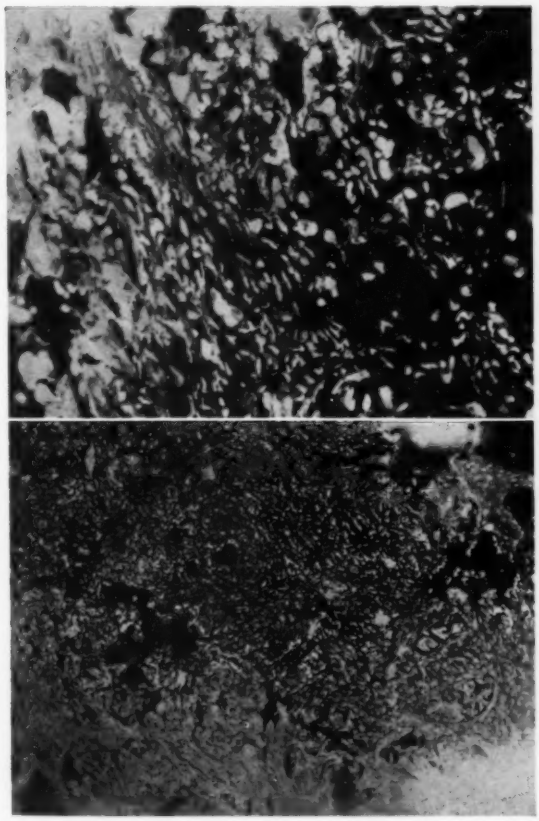


Fig. 25. Case vi.

Biopsy shows undifferentiated carcinoma (Fig. 25).

Case vii. H. R., aged fifty. Pain in the left side of chest; cachexia.

The roentgenogram shows a complete atelectasis of the left lung (Fig. 26).

Bronchoscopy. Stenosis by infiltration of the main left bronchus.

Bronchography. Below the tracheal bifurca-

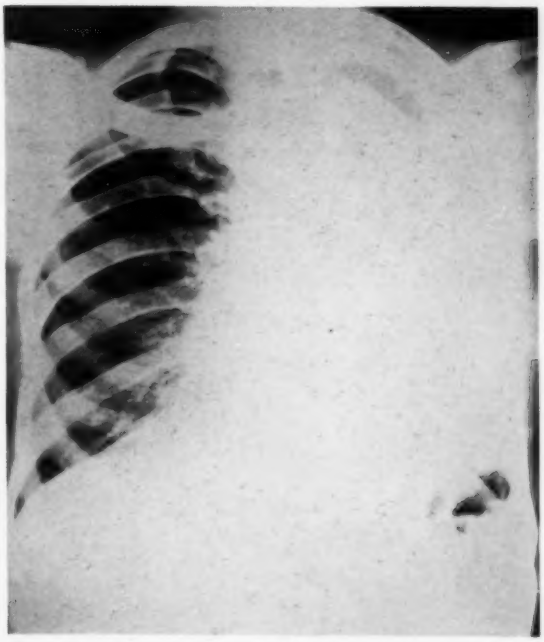


Fig. 26. Case vii.

Fig. 27. Case vii.

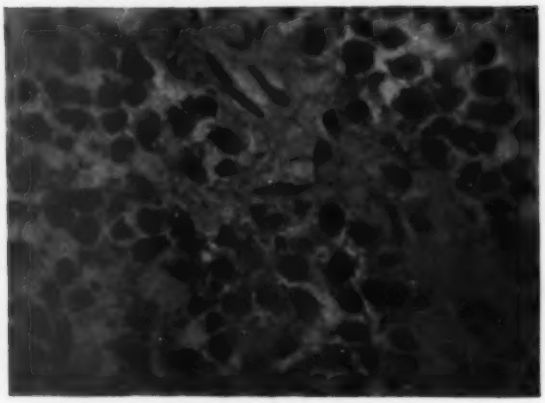


FIG. 28. Case VII.

tion the main left bronchus is narrowed. At its lower border we see a filling defect produced by a polypoid tumor. All its branches are narrowed by infiltration and displaced by extrinsic compression (Fig. 27).

The specimen shows a polypoid tumor at the entrance of the left bronchus and infiltration of all its branches (Fig. 28).

Biopsy shows undifferentiated round cell carcinoma. (Fig. 29).

At times there may be observed in a bronchus of the third or fourth order a polypoid degeneration together with infiltration of the mucosa.

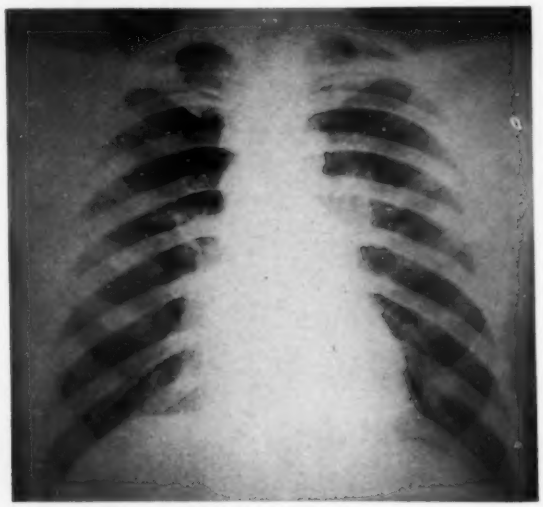


FIG. 30. Case VIII.

CASE VIII. A. D., aged thirty-eight. In February, 1938, hemoptysis.

The roentgenogram shows an increased left hilar shadow and a very small round shadow in the second right intercostal space (Fig. 30). The diagnosis was tuberculosis. Another roentgenogram taken in June, 1939, showed that there was a large nodular tumor at the place of the round shadow (Fig. 31).

The bronchogram shows complete obstruction of the upper lobe bronchus and displacement of the middle lobe bronchus by the tumor (Fig. 32).

Patient had a lobectomy. The specimen shows a large polyp obstructing the entrance of the upper lobe bronchus and very small polyps

FIG. 29. Case VII.

the upper lobe bronchus and very small polyps

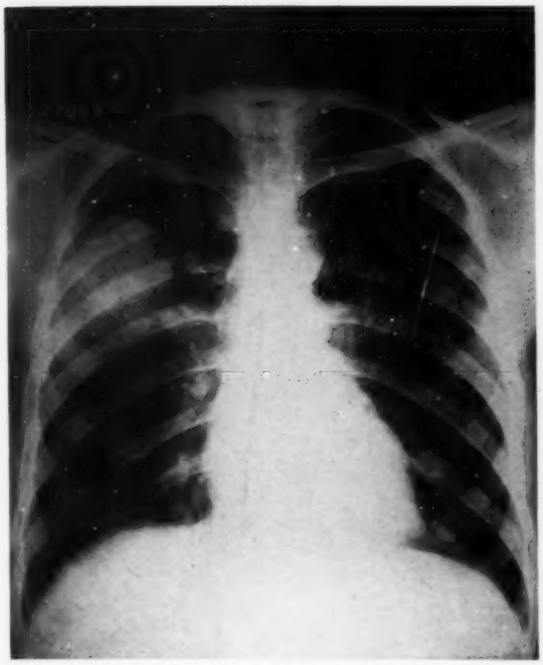


Fig. 31. Case VIII.

and infiltration of the mucosa of the third order bronchi of the upper lobe (Fig. 33).

Biopsy shows glandular epithelioma (Fig. 34).

The bronchial neoplasm in extending to the neighboring pulmonary parenchyma may adopt an infiltrating or nodular form. The infiltrating form reproduces in the parenchyma the type of lesion observed in the bronchus, and appears in the roentgenogram as an irregular shadow with diffuse borders. They are located in the proximity of the hilum, when the bronchial le-

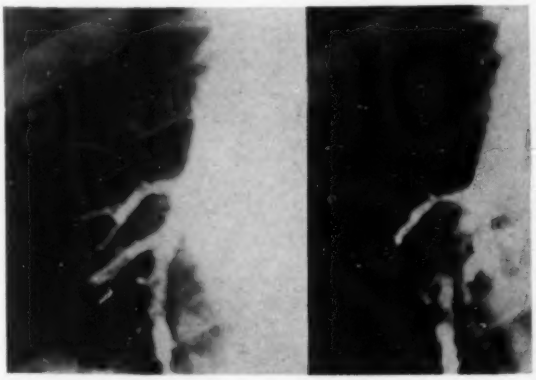


Fig. 32. Case VIII.

Fig. 33. Case VIII.

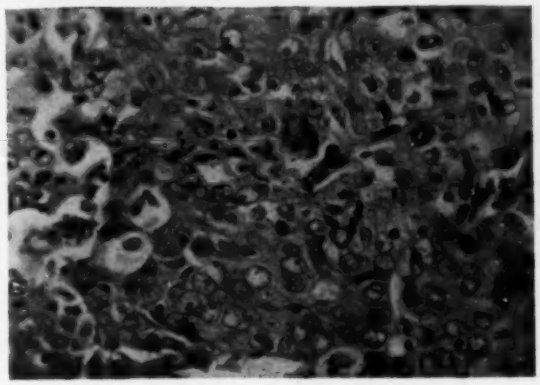


Fig. 34. Case VIII.

sion is situated in the large bronchi, or in the pulmonary field when the primary bronchial lesion is situated in a lobar or in a small bronchus.

The shadows of the neoplastic infiltration of the parenchyma are associated with those of the atelectasis due to the more or less complete obstruction of the bronchus; the shadows of the hilar adenopathy so frequent in this type of neoplasm; the shadows produced by the bronchial dilatations below the narrowed bronchus, and the shadows due to pulmonary suppuration and necrosis with cavitation that occurs in some neoplastic processes. All these added shadows give origin to the enormous polymorphism of primary cancer of the lung.

The nodular forms give origin to dense round shadows with very sharp borders. When they are situated in the apex or infraclavicular region, they give an image that must be differentiated from Assmann's round infiltration. Generally, the malignant infiltrations appear in patients of advanced age; they always have well-defined borders; their density is greater; their size increases from one examination to another.

In the lobar forms of these tumors we observe the same characteristics, and they may produce atelectasis, due to bronchial compression. If necrotic ulceration takes place, shadows similar to those of pulmonary abscess arise.

We present a classification of the roentgenographic aspects of primary carcinoma of the lung (Fig. 35).

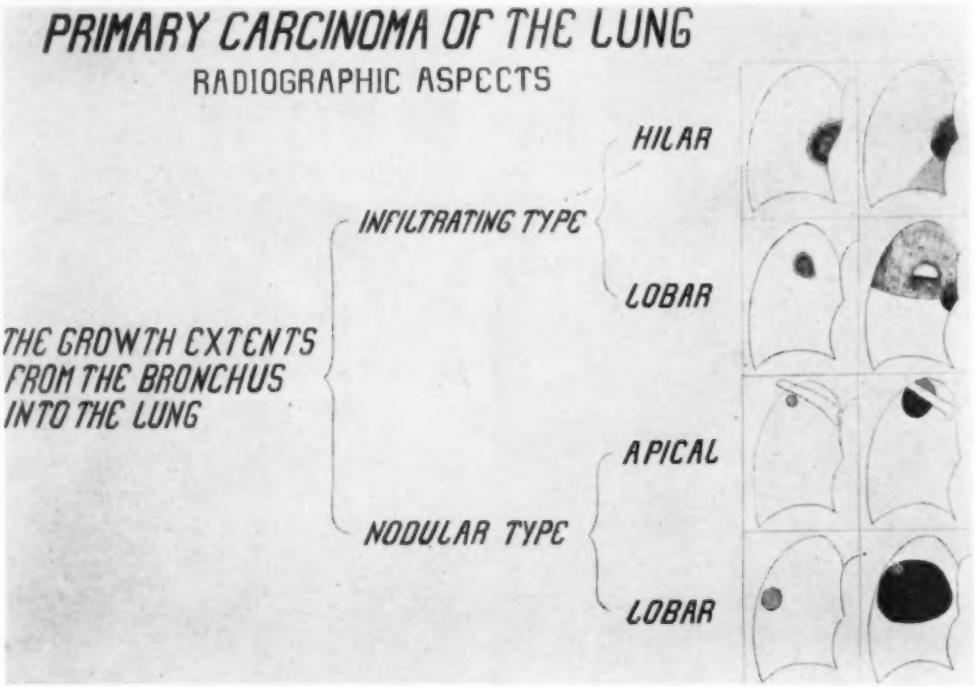


FIG. 35

The infiltrating forms, by their indefinite borders, by the frequency with which they metastasize very easily in the hilar glands and mediastinum, by the undifferentiation of their cells, respond better to deep roentgen therapy than to surgery. As it is possible to determine with precision the extension of the process in the bronchial wall, we may better arrange the ports of entry in deep roentgen treatment, and therefore we are able to administer the large doses of roentgen rays which are required for the treatment of these epithelial tumors, without undue irradiation of large pulmonary fields.

The nodular type, well circumscribed,

with definite borders, of slow growth, is more appropriate to surgery.

The bronchographic examination showing the location and extension of the neoplastic process in the bronchial wall may serve as a guide in separating those cases in which a pneumectomy or a lobectomy is indicated. If the main bronchus or the lobar bronchus is not affected by the process, the surgical indication is that of lobectomy; when the main or the lobar bronchus is affected, a pneumectomy is indicated.

DISCUSSION*

Dr. Edwin F. Hirsch, Chicago. The report by Dr. Golden is of interest to me because it brings up for discussion the opinion of physiologists that a certain length of time is needed for expiration. When there is an obstruction of the bronchus, inhalation starts before the tissues in the obstructed portions have time to collapse. Localized in distribution,these lesions become problems in the roentgenographic interpretation. I wonder whether a localized atelectasis of the lung with regional compensating emphysema might not introduce a complication in the interpretation.

The paper by Dr. Kornblum is of interest because of the close similarity that the lung conditions have to those during the influenza epidemic. The initial onset of this disease with its upper respiratory inflammation, laryngitis, and spread into the lung fit so well the conditions described.

From the anatomic standpoint, of course, we know that the lungs in influenza start with a marked edema and hemorrhage and that the initial lesions in these severe forms soon after the onset are necrosis of the alveolar walls in the lungs. Dr. E. R. LeCount described these very well. Anatomically the influenzal lungs were edematous, the severe forms were hemorrhagic, and then as the disease progressed bronchopneumonia occurred.

In the presentation of the paper I do not think mention was made of terminology, but in the manuscript the question of terminology was introduced, especially the term "pneumonitis." It seems to me that we might use some of the simpler terms that are well known and in good usage and speak of the condition as a "focal lobular or a focal bronchopneumonia" without introducing new terms. With such a simple basic term, the form can be expressed by "marked" or "slight" or whatever else seems appropriate.

As regards the paper by Dr. Sussman on the non-putrid pneumonias, he has defined the problem very closely and very well. I have seen embolic conditions of an aseptic variety in the lung caused by aseptic blood clots. The condition resulting is similar to what he has described as a non-putrid form of pneumonia or infection. The necrotic lung tissues gradually liquefy and are absorbed. The resulting pocket when the walls remain expanded resembles a cyst. These conditions, produced by embolic infarction, will simulate in their late stages the conditions that Dr. Sussman has described.

Concerning the paper that Dr. Sante presented, the question arises whether in the consideration of the various causes there may be a complication of the lung or pleura secondary to an infection from below the diaphragm, but not necessarily with diaphragmatic abscess. I think of the retroperitoneal infections and cellulitis that follow, for example, the electroresection of the prostate.

Discussions of carcinoma of the lung are, of course, of great interest. In many cases the diagnosis is made not by the roentgen ray alone but with other clinical and laboratory examinations. I think especially of the information obtained in patients where the diagnosis is difficult, by the examinations of fluids for cells and with biopsy material removed through the bronchoscope. I had expected Dr. Fariñas to discuss the roentgen therapy of carcinoma of the lungs. Some very hopeless results were reported to me by Dr. Steiner and Dr. Brunschwig. They had little success with roentgen therapy in the treatment of carcinoma of the lungs.

Dr. Lawrence Reynolds, Detroit, Mich. This group of papers represents a very fine exposition of what one can do with the proper arrangement of a program. Beginning with Dr. Golden's paper, in the careful examination which he has made of his patients to determine the question of localized atelectasis or else localized emphysematous changes, he has called attention to a very important point, namely, that often the minimal findings in the lungs may count for much in the ultimate treatment of the patient, and it also entails a knowledge of the physiology of respiration, of which all of

* Discussion on papers of Drs. Golden; Kornblum and Reimann; Sussman; Sante; Olds and Kirklin; and Fariñas.

us should acquire more. A number of interesting papers have been published on it, notably Macklin's interesting articles dealing with the movements of the bronchi and bronchioles during respiration, and it is good to know that Dr. Golden is to continue his study on this particular type of information, which is certainly desirable.

There is one point which I should like to emphasize in these questions of limited atelectasis, particularly in view of one case which he presented showing localized calcifications in the lung undoubtedly of tuberculous origin. In a limited atelectasis in a lung which shows calcification incident to tuberculosis, the possibility of this atelectatic area being secondary to a process of tuberculous origin associated with it elsewhere in a bronchus or bronchiole should be thought of. We have had 3 or 4 cases lately which emphasized that point.

Dr. Kornblum's paper brings up a very interesting question in that he has had a very unusual opportunity to compare a number of normal chests which had been previously studied with the same group that were examined in an influenza epidemic, thereby being able to point out minimal lung changes which might have been overlooked had he not been able to make this comparative study. His study opens a great avenue of investigation in these epidemics because of the great improvements that have been made in bedside roentgen-ray technique.

Dr. Sussman's paper is of importance because of the fact that so many actual lung conditions in these children go unrecognized and the prognostic as well as the therapeutic information in a study of this group of patients is of great importance.

Dr. Sante's paper includes a group of cases which he has discussed from the point of view of differential diagnosis. He called attention to most of the conditions and the methods for their recognition. He failed to mention one more condition to which Dr. Nesbit at the Midwinter Conference of Midwestern Radiologists in Detroit called attention, namely, the possibility of a renal or perirenal abscess being the cause of an empyema and that very frequently this source of the empyema goes unrecognized.

The papers of Dr. Fariñas and of Dr. Kirklin and Olds emphasize anew what Dr. Manges called to our attention several years ago, that every roentgenologist should be "carcinoma of the lung minded."

DR. PAUL HOLINGER, Chicago. The comprehensive nature of the papers and the many new ideas presented stimulate discussion but because of time my remarks will be limited to the bronchoscopic phases. The beautiful demonstration of the careful and complete studies presented by Dr. Fariñas impresses one immediately with the fact that bronchoscopy is now an assumed routine study rather than just an occasional examination.

The work of Dr. Kirklin and Dr. Olds emphasized the aid of the various methods of localization of a pulmonary tumor which the roentgenologist has at his command. Still more accurate information may be gained by the direct inspection of the tracheobronchial tree, but there are a number of complications produced by the tumor itself that make this examination difficult; namely, the distortion, rigidity, extra-bronchial compression, or suppuration. Thus it may be difficult to find or enter normal bronchial orifices otherwise easily inspected. Consequently the aid of the roentgenologist in directing our bronchoscopic procedures fluoroscopically must not be overlooked in the attempt to make an early tissue diagnosis of a bronchogenic carcinoma. I have had a number of opportunities to work with Dr. Jenkinson in this manner and we have removed tissue from otherwise inaccessible bronchi by means of directing the bronchoscope and forceps under biplane fluoroscopic guidance to an area which would have been inaccessible if we had limited our procedure to the field we were to inspect only by means of visual guidance through the open tube. In this manner the periphery of the lung and the upper lobes, through the use of curved forceps, may be reached for biopsy.

Dr. Golden has given us further opportunity for studying small areas of bronchial obstruction and has added another point in the diagnosis of partial obstruction of the bronchus. This again aids in efforts to establish an early diagnosis and may direct us in our search to obtain tissue in a case of unexplained hemoptysis with an otherwise negative chest roentgenogram. The extreme motion which Dr. Golden discussed is beautifully demonstrated as we attempt to remove small metallic foreign bodies from the periphery of the lung under the fluoroscope.

Time will permit me to say only a few words regarding the interesting study of Dr. Kornblum and Dr. Reimann. During the past few

months we have seen a number of patients with bronchiectasis who dated the onset of their symptoms to the 1939 "flu" epidemic. In none of the cases was a roentgenogram of the chest taken at the time of the "flu" and consequently this study adds a very important link to the series. I should like to ask Dr. Kornblum whether subsequent roentgenograms have been taken of the 24 patients with acute tracheobronchitis or of the 22 with atypical pneumonia. If any have developed bronchiectasis, the course of development would be clear with these studies, i.e., the length of time the roentgen findings were present in the acute stage in proportion to the amount of permanent damage remaining. Was there any indication regarding the degree of atelectasis present in the cases of lower lobe atypical pneumonia?

ROENTGENOLOGICAL OBSERVATIONS IN LEPROSY

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WE WISH to discuss in this paper certain observations of the changes in the bones of lepers, as shown by the roentgen ray, in connection with the two principal types of the disease, i.e., nerve leprosy, or tuberculoid leprosy, and skin or lepromatous leprosy. A short summary of the essentials of these types might be of value.

a. Tuberculoid leprosy is that form of the disease consisting of macules of various clinical forms, generally poor in bacilli, with involvement of the cutaneous nerves, histologically essentially tuberculoid. There may be nerve lesions of the larger nerve trunks with or without macules in cases which have never been lepromatous. These types of nerve lesions are tuberculoid. They are well defined, abruptly limited in one or more of the larger nerve trunks. The strong tissue reaction in this type results, in spite of only a few bacilli present, in a very intense destruction of afferent and efferent nerve fibers in the area concerned.

b. Lepromatous leprosy is that form in which the skin lesions show many bacilli and little or no involvement of the cutaneous nerves. Histologically we find the characteristic foam cells as the distinguishing mark. The nerve trunks may be involved as well. The infiltration of the nerves is, however, much more diffuse and does not show the marked localization of the tuberculoid type. The destruction of nerve fibers is consequently not as rapid as in tuberculoid leprosy. Transitions from one form to the other occur. We have tried, in our investigation, to select only those cases which are definitely tuberculoid or definitely lepromatous.

Since many of the papers written on the subject of bone changes in leprosy are not at our disposal, we shall not discuss previous findings, but restrict our discussion to our observations and what we believe to be their possible explanation. The cases selected were from the Chiengmai Leper Asylum. The case records and roentgenological observations are as follows:

REPORT OF CASES

Tuberculoid (Nerve Leprosy) Cases

CASE I (1086). Male, aged nineteen. Seven years ago he noticed a raised patch on the face. Later these patches spread over his trunk. He now exhibits large, flat, fatty patches on his trunk, all of them anesthetic. Hands and feet show marked muscular wasting with slight contractures of fingers and toes (Fig. 1*A*). Hands and feet are anesthetic.

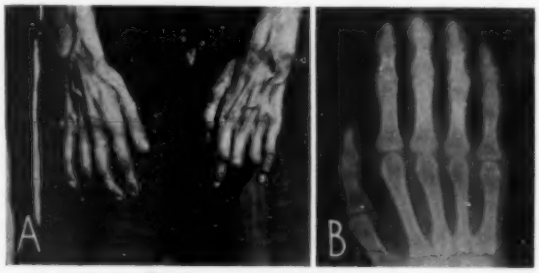

FIG. 1, *A* and *B*. Case 1.

Roentgenology of Hands. The outline of carpals, metacarpals and phalanges is normal. No periarthritic infiltrations. There is moderate rarefaction of shadow-giving substance in all the bones concerned. Slight dislocations of joints, due to contractures, are visible (Fig. 1*B*).

CASE II (271). Male, aged forty-one. Thirty years ago there were patches on the left leg and right arm, later anesthesia of right arm and left leg. He now shows no visible skin lesions. The right hand and forearm and left leg show marked muscular wasting. Facial paralysis. Drop-foot, left. Right hand shows contractures, claw formation (Fig. 2*A*). "Monkey hand". Right hand and forearm and left leg are anesthetic.

Roentgenology of Hands. Left hand apparently normal. Right hand shows deformities of position (contractures). There is slight peri-

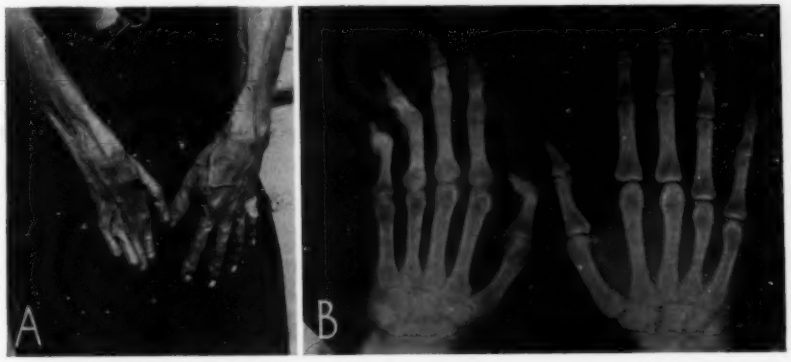

Fig. 2, *A* and *B*. Case II.

arthritic infiltration of two terminal phalangeal joints. Compacta of carpals, metacarpals and phalanges is much thinner than in the normal left hand. Interspongious spaces are wide, spon-

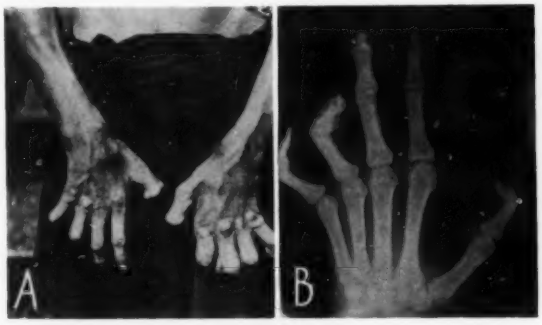

Fig. 3, *A* and *B*. Case III.

gious walls thin and rarefied. This rarefaction is particularly well marked in the distal epiphyses of all metacarpals, in the proximal epiphyses of the basal phalanges, and in the sesamoid bone of the thumb (Fig. 2*B*).

Case III (369). Male, aged twenty-three. Ten years ago there was a patch on the thigh, later mutilations of hands and feet. He now shows no visible skin lesions. Feet show deformities and ulcers. Hands show marked muscular wasting, hyperkeratosis of knuckles, contractures—claw-hand (Fig. 3*A*). Hands and legs are anesthetic.

Roentgenology of Hands. There are marked dislocations due to contractures, no periarthritic infiltration. Spongiosa and compacta of carpals, metacarpals and phalanges show rarefaction of shadow-giving substance (Fig. 3*B*).

Case IV (301). Male, aged seventy-six. Twenty-five years ago he had a patch on the chest, later mutilations. He now shows, apart from senile atrophy of the skin, no visible skin lesions. Slight mutilation of right toes. Right foot and leg and left foot are anesthetic. Both hands show muscular wasting. Left hand shows contracture of small finger; ulnar part of left hand and forearm anesthetic. Right hand shows marked contractures and shortening of fingers (Fig. 4*A*). Right hand and forearm anesthetic.

Roentgenology of Hands. Carpals, metacarpals and phalanges of both hands show marked rarefaction of shadow-giving substance, more

Fig. 4, *A* and *B*. Case IV.

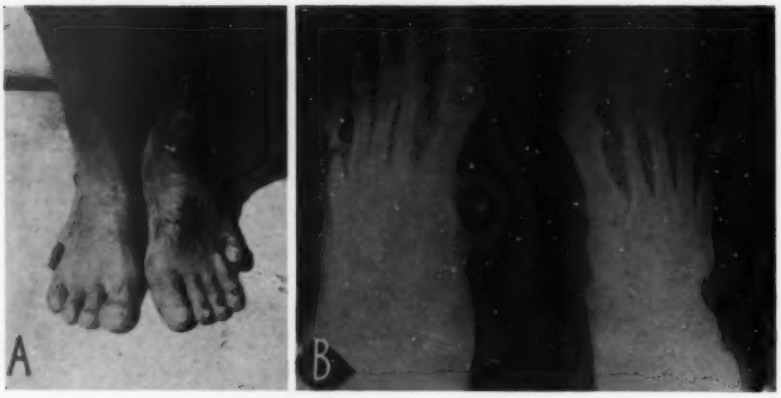

FIG. 5, *A* and *B*. Case v.

marked in right hand. In the left hand the rarefaction is most marked in the little finger which is contracted and slightly dislocated in the metacarpophalangeal joint. Right hand shows marked rarefaction of the sesamoid bone of the thumb. Distal phalanges are rarefied and have partly disappeared, particularly in the fifth digit. Distal epiphyses of the fourth and fifth basal phalanx have disappeared. There are marked contractures, which make judgment difficult (Fig. 4*B*).

CASE V (713). Male, aged twenty-nine. Eight years ago he had flat white patch on the back, later numerous patches on the trunk and slight mutilations. He now shows numerous slightly raised annular or plaque-like "minor tuberculoid" patches on the trunk. The patches are anesthetic. Hands and legs are anesthetic. Both feet show retraction and dislocation of small toes (Fig. 5*A*).

Roentgenology of Feet. Tarsal skeleton is not visibly affected. The first to the fourth metatarsals show normal corticalis and spongiosa in the diaphyses. The distal diaphyses and distal epiphyses show marked rarefaction of compacta and enlargement of interspongious spaces. Similar rarefaction is noted in the first to fourth phalanges. Fifth metatarsal (left foot): external part of corticalis is markedly thin. Spongiosa of diaphysis rarefied. Distal epiphyses not visible. Diaphysis is shortened and grows thinner in the distal direction. The fifth basal phalanx, though markedly reduced in shadow-giving substance, retains in its distal part, together with the fifth distal phalanx, its original shape. Its proximal epiphysis is broken in outline and pressed against the sharp distal end of the fifth metatarsal. The fifth metatarsal and the fifth phalanx of right foot show corresponding disturbances. The fifth basal phalanx is not so distinctly pressed against the distal end of the fifth metatarsal as in the left foot. The proximal epiphysis is, however, distinctly eroded (Fig. 5*B*).

CASE VI (117). Male, aged fifty-five. Twenty-eight years ago he had a flat white patch on the back, later slight mutilations. There are now a few fading patches on the trunk, and right facial

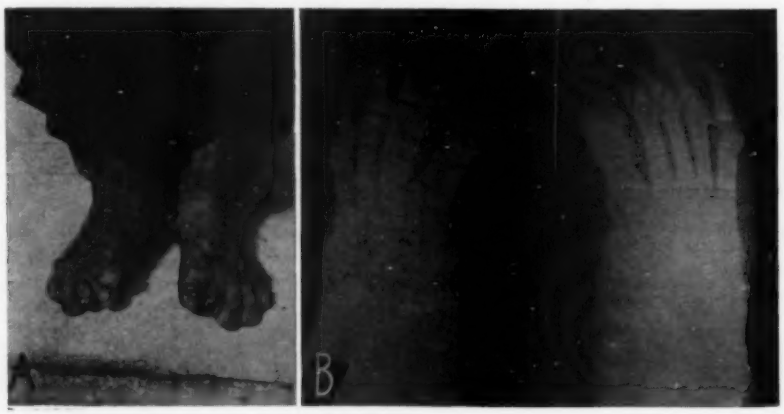

FIG. 6, *A* and *B*. Case VI.

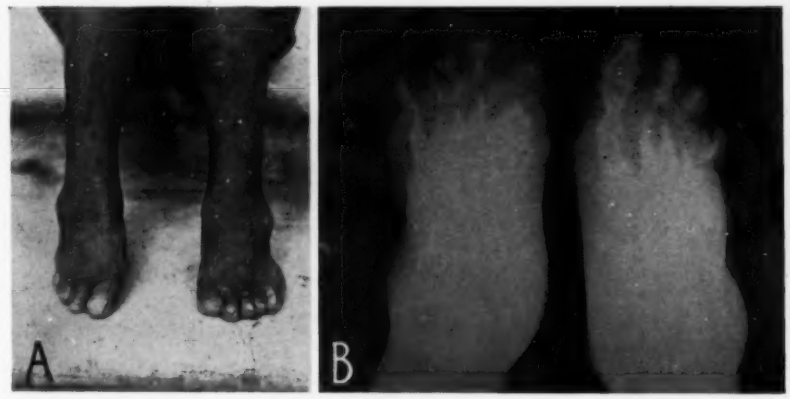

Fig. 7, *A* and *B*. Case vii.

paralysis. Wasting of interossei and ulnar anesthesia of hands. Feet are anesthetic, show wasting of interossei, dislocation of toes, several scars of sole and toes due to healed ulcers (Fig. 6*A*).

Roentgenology of Feet. Both feet show rarefaction of compacta and spongiosa, particularly in the distal epiphyses of all the metatarsals. Some of the distal phalanges are not visible. There is marked and well localized periostitis ossificans in both first metatarsals. Some joints show densely calcified villous areas, which in parts are like arthritis deformans. The fifth metatarsal of the left foot is eroded at the external aspect of the distal epiphysis. The first metatarsal of the right foot shows two exostoses. The periarthritic, ossifying osteitic and ossifying periostitic foci seem to have been caused by ulcerations which are now healed (Fig. 6*B*).

Case vii (213). Male, aged forty-four. Thirty-eight years ago he complained of a patch on his back, later mutilations. He now shows a fading, anesthetic patch on his back. Hands, arms, feet and legs are anesthetic. Mutilations of hands and feet (Fig. 7*A*).

Roentgenology of Feet. The findings are the same in both feet. There is marked rarefaction of all the diaphyses of the first to fifth metatarsals. Their distal epiphyses are not visible and the shafts stand out sharply without connection to the basal phalanges. The basal phalanges have disappeared, except for a few remains of the distal epiphyses. The medial and distal phalanges are markedly rarefied but well preserved in outline (Fig. 7*B*).

Case viii (65). Male, aged fifty-eight. Thirty-five years ago he had flat patches on the trunk, later mutilations. He now shows fading anesthetic macules of the trunk, mutilation of hands and feet. Hands, arms, feet and legs are anesthetic. Wasting of muscles of right leg. Right foot shows loss of two toes and is shorter than left foot, which has lost one toe. Scars of ulcers on right sole (Fig. 8*A*).

Roentgenology of Feet. Both feet show marked

Fig. 8, *A* and *B*. Case viii.

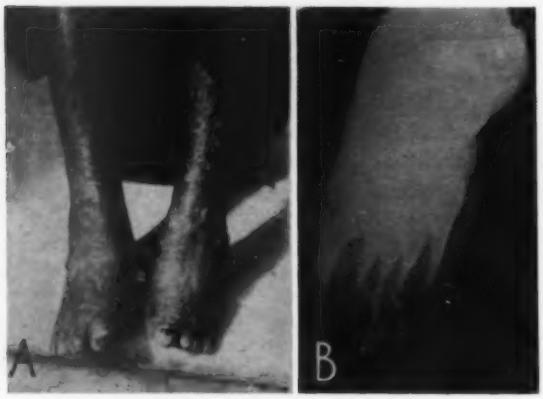

FIG. 9, *A* and *B*. Case IX.

rarefaction of tarsals, metatarsals and phalanges. The first, second and fifth phalanges of the right foot are not visible. The distal epiphyses of metatarsals and proximal epiphyses of basal phalanges are not visible. The distal ends of diaphyses of metatarsals and proximal end of diaphyses of basal phalanges are sharp and pointed. There is pericortical infiltration of the first metatarsal, probably an old ulcer (Fig. 8*B*).

CASE IX (39). Male, aged fifty. Forty years ago he complained of a white patch of the face, later patches of trunk, mutilations. He now shows general senile atrophy of the skin, with slightly scarred areas of trunk, anesthetic, mutilations of hands and feet. Face, hands, arms, legs and feet are anesthetic. Feet show shortening of proportions and slight dislocation of toes (Fig. 9*A*).

Roentgenology of Feet. Left foot shows rarefaction of all bones. Phalanges not visible. First to fifth metatarsals shortened and pointed distally. Right foot shows rarefaction of tarsals. In the first metatarsal the rarefaction is most marked in the distal epiphysis. There is periostitis ossificans and callus formation in the distal epiphysis of the first metatarsal (ulcer?). The first basal phalanx is visible only in some proximal remains. The second metatarsal shows much rarefaction. The distal part of the diaphysis and the distal epiphysis are not visible. The pointed end of the diaphysis is overlapped by the second basal phalanx, which is rarefied and pointed proximally. Only small epiphyseal remainder of terminal second phalanx is visible. The third metatarsal is very rarefied, distal parts not visible. The third basal phalanx is not visible apart from the distal epiphysis. The terminal phalanx is small and rarefied. The findings in the fourth basal phalanx correspond with the second. In the fifth there is marked rarefaction of distal diaphysis and epiphysis. The fifth basal phalanx is proximally rarefied (Fig. 9*B*).

The following two cases have probably at times been lepromatous, though they are now essentially nerve cases. Both cases were at times positive for acid-fast bacilli.

CASE X (222). Male, aged fifty-six. Thirty-eight years ago he had anesthesia of hands, later generalized patches. He now shows fading patches of trunk, not anesthetic, facial paralysis, mutilations of hands and feet. Hands, arms, feet and legs are anesthetic. Hands show mutilated, contracted fingers with little muscular wasting (Fig. 10*A*).

Roentgenology of Hands. There is marked rarefaction of carpals, metacarpals and phalanges. There is a circular shadow in the distal epiphysis of the left fourth metacarpal (periostitis ossificans? leproma?). The right hand

FIG. 10, *A* and *B*. Case X.

shows normal outlines of the third, fourth and fifth basal phalanges, except at the distal joints, where periarthritic infiltrations are visible, which may, however, be only the remains of proximal epiphyses of the medial phalanges. In the fourth basal phalanx part of the diaphysis of the medial phalanx is visible. The second basal phalanx is visible only in its proximal parts. The first basal phalanx shows remains of epiphyses. The left hand shows similar changes (Fig. 10*B*).

Case xi (215). Male, aged forty. Twenty-five years ago he had a patch on the right leg, later numerous patches on the trunk, mutilations. He now shows numerous fading patches on the trunk, not anesthetic. Mutilations of hands and feet. Hands, arms, feet and legs are anesthetic. Hands show shortening of fingers and slight muscular wasting (Fig. 11*A*).

Roentgenology of Hands. All bones concerned show marked rarefaction. Outlines of carpals and metacarpals are normal. Basal phalanges show thin diaphyses, partial loss of distal epiphyses and flattening out of some proximal epiphyses. The sesamoid bone of the left hand is reduced. Medial and terminal phalanges visible only in remnants in thumbs (Fig. 11*B*).

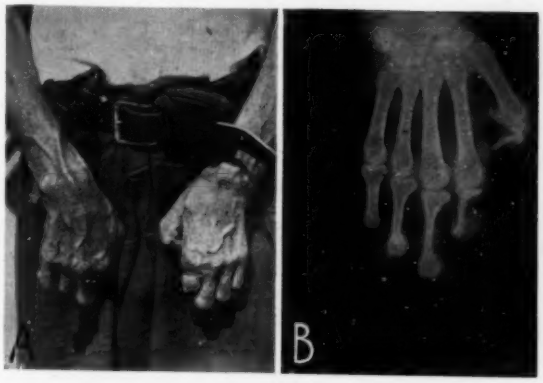

Fig. 11, *A* and *B*. Case xi.

Lepromatous Cases

Case xii (593). Male, aged forty. Eighteen years ago he had numbness of thigh, later nodules of face. He now shows retrogressive infiltra-

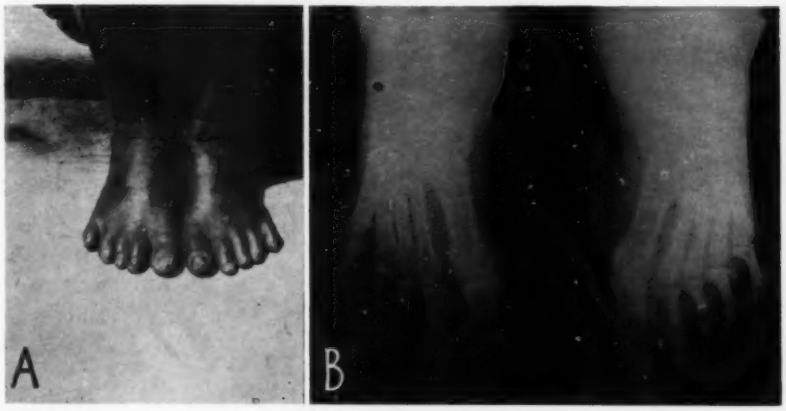

Fig. 12, *A* and *B*. Case xii.

Fig. 13, *A* and *B*. Case xiii.

tion of face and ears. Skin of legs and hands atrophic, shining. Toes appear slightly shortened (Fig. 12*A*). Hands and feet are anesthetic.

Roentgenology of Feet. Distal parts of metatarsals and all phalanges show marked rarefaction. No periarthritis; no periostitis (Fig. 12*B*).

CASE XIII (1040). Male, aged thirty-eight. Twenty-three years ago he complained of numbness of right elbow, later nodules of face. He now shows moderate infiltration of face and ears; atrophic skin. Mutilations of hands and feet, both anesthetic (Fig. 13*A*).

Roentgenology of Hands. There is moderate rarefaction of carpals, metacarpals and phalanges. Carpals and metacarpals well defined in outline, except two exostoses of the fifth metacarpal and the second basal phalanx (ulcers). Diaphysis of basal phalanges thin, distal epiphyses eroded. Only small remains of medial and distal phalanges visible (Fig. 13*B*).

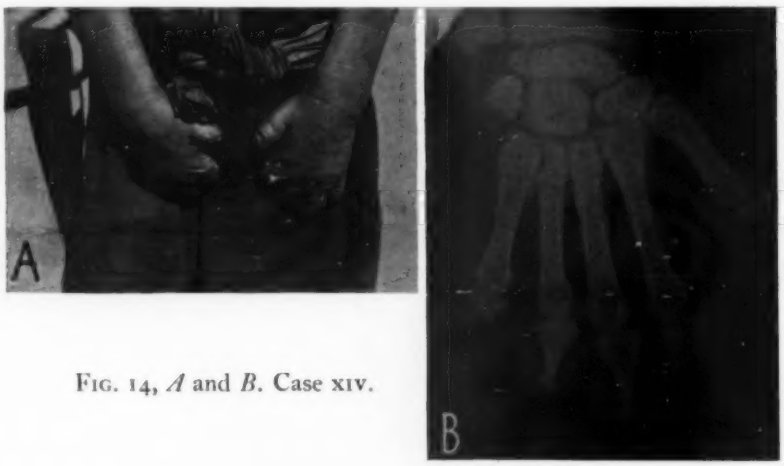

FIG. 14, *A* and *B*. Case XIV.

CASE XIV (1100). Male, aged twenty-six. Twelve years ago he had a flat patch on the right arm, later thickening of ears and mutilations. He now shows irregular thickening of ears, facial paralysis, general trophic changes of skin. Hands and feet extremely mutilated, anesthetic (Fig. 14*A*).

Roentgenology of Hands. There is marked rarefaction of carpals, metacarpals and phalanges. Carpals and metacarpals show normal outlines. Basal phalanges are visible only in proximal remains, terminal phalanges not visible (Fig. 14*B*).

SUMMARY OF FINDINGS

A. In nerve leprosy unilateral disturbances of bones—and of nerves—are not infrequently seen (Cases II and IV), while in lepromatous leprosy the involvement is usually bilateral and symmetrical. (This is confirmed by numerous cases, not included in this paper.)

B. The essential characteristic of bone disturbance is a rarefaction of shadow-giving substance in nerve leprosy as well as in lepromatous cases. Periostitis ossificans is seen in a few foci in Cases VI, VIII, IX and X. In all these cases the ossifying foci are situated near old scars of ulcers so that it can reasonably be inferred that periostitis ossificans in leprosy is a consequence of secondary infection through deep, trophic ulcers.

Only in Case X do we find a focus which might be a leproma of the bone marrow. It is understood that in lepromatous cases the bone marrow may be diffusely infiltrated. We are, however, inclined to think that the peculiar atrophy of bone structure, which we see in nerve cases and in lepromatous cases alike, is not essentially a consequence of direct inflammatory reaction against *Mycobacterium leprae* in the bone.

Arthritis deformans is, in our opinion, not an essential factor either in the production of contractures or of the structural

atrophy. In Case II there are very slight periarthritic infiltrations. In the more advanced cases we miss them entirely except in Case VI, where their origin is likely to be the same as the marked ossifying periostitis, namely ulceration and secondary infection.

We conclude that the structural changes in the bones of lepers are essentially a consequence of nutritional, trophic disturbance, which we shall now discuss in detail.

The nutrition of the bones of hands and feet is supplied from two important sources.

a. The central nutritional arteries, which are derived directly from the arteries of the area concerned. They supply the bone marrow and communicate with the second source. The amount of blood carried in them is regulated by sympathetic nerve fibers which arise from the plexus sympaticus of the larger arteries and which have no direct connection with the larger spinal nerve trunks. Spasms of the nutritional artery give rise to the diseases called aseptic necrosis, Kienböck's disease, etc., in the bones of hands and feet.

b. The periosteal arteries, which originate from vessels supplying the muscles, and reach the periosteum through the muscular insertion. The amount of blood carried to them depends on the blood supply of the muscle, which again is regulated by intact motor nerves and training of the muscle. An increase of shadow-giving substance has been observed after exercise at the muscular insertion.

The sympathetic nerves, which regulate the central nutritional arteries of the bones, are little or not at all affected in leprosy. We assume therefore that the most important cause of atrophic changes in the bones of lepers is the interference with the periosteal vessels. This interference is caused by a more or less marked destruction of the motor nerve fibers which supply the muscles of the bones concerned. A closer study of the differences between nerve involvement in tuberculoid and in lepromatous cases brings the proof of this assumption.

a. Nerve affection in tuberculoid leprosy. We wish to deal here not with the ascendant lesions in cutaneous nerves, but with either ascendant or metastatic lesions in large nerve trunks. The nerve lesions of the tuberculoid type are well limited. They are very destructive on account of the vigor of tissue reaction, and they show some definite affinity for certain places. In the upper extremity the ulnar nerve, just above the elbow, is most commonly affected. Such a lesion would destroy many nerve fibers supplying areas beyond it. The median is less commonly affected, but if so, the lesions are usually found just above the wrist, where the nerve enters the carpal canal. Nerve fibers arising distal to this area are likely to be destroyed, while those above generally escape. The radial is much less frequently affected in its motor tracts. In the lower extremity the peroneal nerve plays the rôle of the ulnar. Lesions are frequently found where it turns around the head of the fibula. The posterior tibial is frequently affected on its way around the ankle so that fibers originating above that area will escape degeneration, while those distal are likely to be disturbed. The musculocutaneous nerve is rarely affected.

b. Lepromatous nerve involvement is much more diffuse, with the marked predilection of tuberculoid infiltration. All nerves are affected in the same degree and it is obvious that smaller branches to small muscles will suffer more heavily than larger ones.

Figure 15 shows the muscle insertions on the bones of the hands and feet and indicates the enervation of the respective muscles.

Let us now analyze our cases:

1. *Cases of Nerve (Tuberculoid) Leprosy.*

a. Hands: Cases I to IV show various degrees of atrophy of bones and contractures. The atrophy is most marked in the distal epiphyses of the metacarpals and in the proximal epiphyses of the basal phalanges. The disturbance is most marked in the fifth and fourth digits. It will be noted

that these areas belong to bones the muscular attachments of which are entirely supplied by the ulnar nerve, or branches of the median beneath the wrist.

b. Feet: Cases v to ix show in various degrees the following changes most marked in the fifth digit: atrophy and partly complete disappearance of the distal ends of the metatarsals and of the proximal ends of the basal phalanges. The proximal phalanges apparently resist destruction much longer. It will be noted that these areas belong to bones which are inserted by muscles supplied by the peroneal nerve and by the posterior tibial beneath the ankle. The terminal phalanges are inserted by muscles which are enervated by the posterior tibial above the ankle.

2. *Cases of Lepromatous or Tuberculoid Leprosy Which Have at Times Been Lepromatous.*

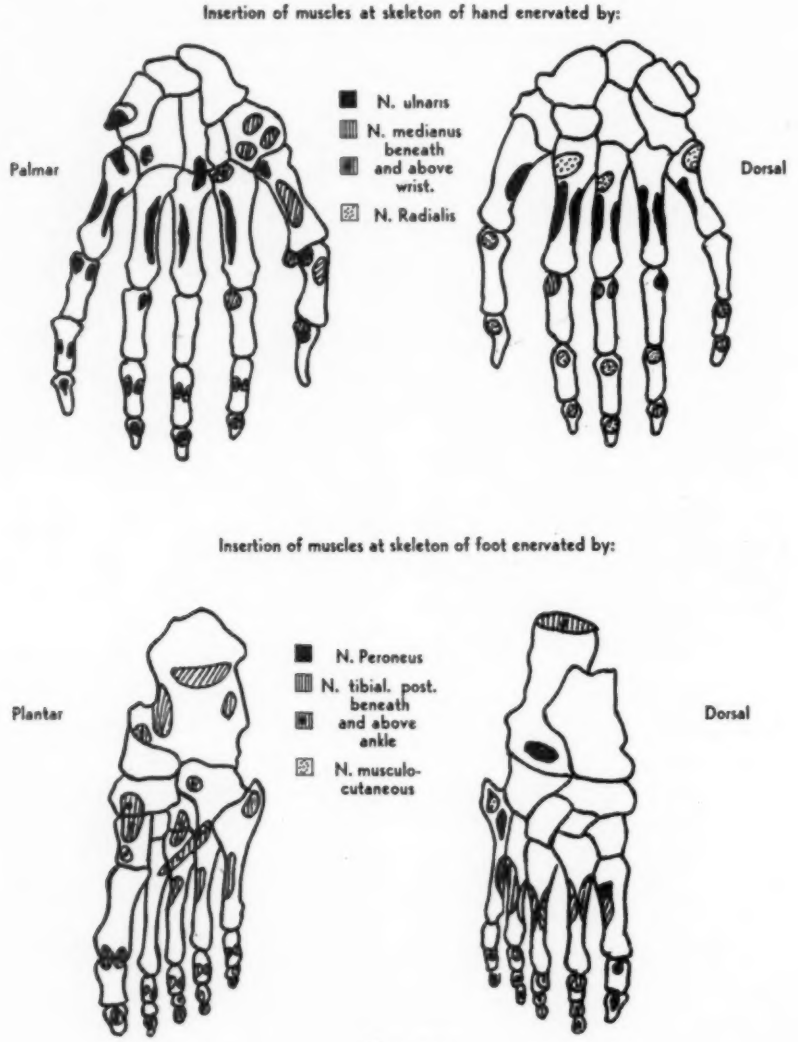

FIG. 15

a. Hands (Cases x, xi, xiii and xiv): These cases show, besides marked atrophy of all bones concerned, that the complete destruction of bones is confined to the distal ends of the phalanges without predilection to certain areas as in tuberculoid cases (except Case x which has been essentially tuberculoid).

b. Feet: Case xii shows general atrophy of bone only, without predilection of localization.

DISCUSSION

We find that in tuberculoid leprosy the bone atrophy begins and is most marked in those bones whose muscular insertions are supplied by frequently damaged nerves like the ulnar, median beneath the wrist, peroneal and posterior tibial beneath the ankle. In lepromatous cases, however, the atrophy begins and is most marked at the distal ends of the digits. We assume that the disturbance of nutrition which causes the roentgenological changes is due to inactivation of muscles inserting on the bones concerned. This inactivation is due to more or less marked destruction of motor nerve fibers. While in tuberculoid leprosy this destruction is confined to some predilected nerves, thus causing destruction of a few bones while leaving others, regardless of size, comparatively undisturbed, we find that in lepromatous leprosy nerve involvement is diffuse and therefore results in destruction first of those bones which quantitatively have a smaller area of muscle insertion (terminal phalanges), regardless of the predilected spots of nerve involvement. This of course cannot be considered as a definite statement as transitional forms may occur (Cases x and xi).

An important therapeutic lesson may be learned from this investigation. It is obvious that purposive training of the muscles concerned is likely to prevent the sad final stages of nerve leprosy, and the orthopedic recommendations, recently brought forward by Dow, should be considered by all leprologists.

SUMMARY

1. Roentgenological observations have been made on the bone disturbances in 14 cases of leprosy.

2. The essential finding in mutilated hands or feet is atrophy of the corticalis and spongiosa in various degrees.

3. This atrophy is ascribed to nutritional changes in the bone, which are caused by insufficient blood supply through the periosteal vessels.

4. This insufficiency is caused by various degrees of muscular atrophy which is due to leprotic involvement of the nerve trunks.

5. The localization of atrophy in the bones gives rise to a differentiation between tuberculoid and lepromatous leprosy, caused by the different modes of nerve involvement in the two.

6. The necessity of active orthopedic therapy is emphasized.

XANTHOMATOSIS (LIPOIDOSIS, SCHÜLLER-CHRISTIAN TYPE)*

REPORT OF CASE

By DOUGLAS S. KELLOGG
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THE term xanthomatosis has been used to include a rather wide variety of conditions. Sosman classified these under five headings: Gaucher's disease, Nieman-Pick's disease, Schüller-Christian's disease, the xanthomas occurring in icterus, diabetes and pregnancy, and those called essential xanthomatosis. Epstein and Lorenz suggested the term lipoidosis for the group, with a modifying term to indicate the type. For example: lipoidosis, Schüller-Christian type. However, certain of the conditions labeled xanthomas may not belong in the lipoidosis group. Geschickter and Copeland have studied many of the so-called xanthomas of tendons and tendon sheaths, and believe that they are giant cell tumors arising from some vestige of the original structure of the sesamoid bones. They state that the most convincing proof of this is indicated by the histology of the tumors themselves, for some vestige of the original structure of the sesamoid bones is usually visible under the microscope. They noted that special study on this point reveals that the pink-staining network of tissue observed in the sections is the remains of white fibrocartilage from which tissue the sesamoid bones are derived. They found that all these cases having typical giant cell areas were found to coincide in location with sites of the sesamoid bones. In the cases in which these xanthic tendon sheath tumors do not occupy the site of the sesamoid bones, miroscopic examination shows that they do not have the typical giant cell structures. They believe that these belong more properly to the fibrohemangiomas, fibromas or ganglia. However, the other conditions mentioned above, Gaucher's disease, Nieman-Pick's disease, Schüller-Christian's disease and the xanthomas occurring in icterus, diabetes and pregnancy, do have a common etiology in that there is a disturbance of lipoid metabolism.

The diagnostic triad reported by Christian consists of the defects in the membranous bones, diabetes insipidus, and exophthalmos. All of this triad is not necessary, however, to establish the diagnosis. Strong, in reporting his case and reviewing previous reports, believes that the skull defects must be present to be diagnostic. However, Sosman, who has made a considerable study of this subject, emphasizes that no one of the triad is essential.

Sundelius made a careful review of the literature and found 80 cases of the Schüller-Christian type of this disease. From 63 of these he was able to chart the frequency of the various symptoms. This showed that the symptoms of the triad head the list. The first three, in order of frequency, are the skull defects, diabetes insipidus, and exophthalmos. The combination of the three together is next most frequent in occurrence. Then follow the involvement of the pelvic bones, skin lesions, arrest in growth and others of less frequency. Sundelius was also able to chart the initial symptom in 57 of the cases he found in the literature. He showed that one of three symptoms occurred first in 75 per cent of the cases; namely, skull defects, diabetes insipidus or gingivitis. The presence of bony defects in the skull was the initial symptom found in over one-third of this series.

The age incidence shows this disease to be primarily one of the first decade of life. Dauksys made an extensive search of the literature and found what he thought were

* From the Roentgenological Service, Station Hospital, Headquarters Eighth Corps Area, Fort Sam Houston, Texas.

124 cases of xanthomatosis, including his own. Nearly one-half of this series were under six years of age. Two-thirds were twelve years or under. After the first decade, the age incidence is fairly evenly distributed, there being a slight rise in the number of cases in the third decade. Sosman published reports of 6 cases of his own in 1932. One of them had previously been a patient of Christian, who originally reported the case in 1919. Five of these 6 cases were under six years of age. One was fifty-five years old.

The differential diagnosis of these osteolytic lesions of the skull offers a considerable problem. Those most closely simulating the massive skull lesions of xanthomatosis, in extent, are cholesteatoma and osteoporosis circumscripta. The latter condition is generally considered as an early phase of Paget's disease, it being the demineralization before the sclerotic stage. Sosman coined the term "monophasic Paget's" for this condition. It occurs primarily in the age period forty to sixty. On the film it appears as a demineralization rather than a complete loss of substance and usually shades off smooth and regular in outline. Usually other bones are involved, and this condition does not respond to radiation therapy. In xanthomatosis, the lesions are sometimes multiple and smooth in outline. Often they have a "geographic" or "map-like" appearance. The area of involvement may become very large, and is irregular in outline. There may or may not be an increase of the cholesterol content of the blood.

Cholesteatoma is a much slower developing lesion than xanthoma. It becomes extensive in involvement, but is usually regular in its general contour. There may be dense trabeculae separating the destroyed areas, giving a somewhat polycystic appearance. It does not respond to radiation therapy.

Nonspecific osteomyelitis may have an appearance on the film simulating xanthoma, as both usually show the irregular contour. However, osteomyelitis is usually more rapid in development, even though at times it is very slow. The symptoms, too, are usually quite marked. On the roentgenograms, there is nearly always evidence of considerable bone production in the attempt at repair, and there is often sequestration. It does not show the spectacular response to radiation therapy that xanthomatosis does.

Other conditions producing osteolytic lesions of the calvarium can usually be ruled out, such as tuberculous or syphilitic osteomyelitis, metastatic lesions, myelomata and meningioma. The first four will usually show manifestations elsewhere. The myelomata have a characteristic appearance on the film which consists of multiple, small, rounded areas of bone destruction. Meningioma usually shows signs of increased intracranial pressure, and its accompanying symptoms.

REPORT OF CASE

The case is that of a white male, aged twenty-nine at the time he was first seen. His family and personal history are essentially negative. He had measles, mumps, and whooping cough when a child. He denied any venereal disease. He first came under observation in April, 1935, with the complaint of intermittent periods of soreness on the right side of his head in the temporoparietal region. The only injury he had had was one in 1932, from which time he dated his trouble. He stated that in October or November, 1932, he sustained an injury just above his right ear when he was struck a glancing blow by a falling antenna pole. He is a soldier and is a radio operator in a signal company. The accident occurred while setting up a field radio station. He stated that at the time of the injury he did not consider it severe and said that his scalp was not cut. Since then he has had periods when he noticed a slight soreness, or aching feeling, in the region of the injury. This seemed to be aggravated by the wearing of ear phones. Between these periodic attacks he had no symptoms at all.

The general physical examination was negative. Roentgen examination of the skull was first made in April, 1935 (Figs. 1 and 2). At that time there was noted an irregular bone defect in the anterior portion of the right

FIG. 1. Destructive bone lesion, right anterior parietal region of skull, as first seen in April, 1935.

FIG. 3. Skull defect as seen in March, 1937, at the time roentgen therapy was instituted. Note the marked extension of the destructive process anteriorly, superiorly and posteriorly.

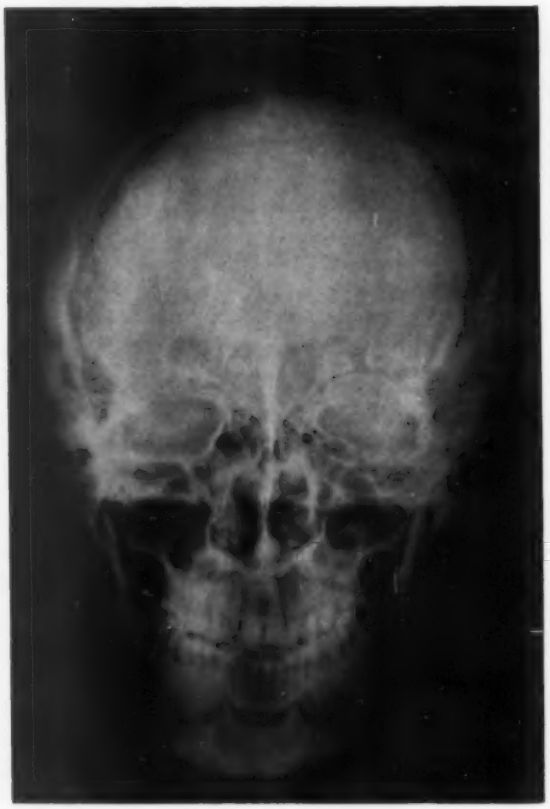

FIG. 2. Posteroanterior view made at about the same time as Figure 1.

FIG. 4. Posteroanterior view at same time as Figure 3.

parietal bone measuring about 6.0×3.5 cm. in its greatest diameter. The margins of the defect had a moth-eaten appearance. Because the patient was otherwise in excellent physical condition, the surgical staff did not feel justified in operative interference, for either exploration or biopsy.

The patient next appeared in the roentgen

department in August, 1936, a year and four months later, at which time it was noted that there was a slight puffy swelling over the right temporal and parietal region. Roentgenograms at that time showed a considerable extension of the bone defect upward and backward in the right parietal bone, and a small additional area extending into the frontal bone. There was some recalcification in the lower portion of the bone defect as compared with the previous films. There was little change in the symptoms, aside from a slight puffiness in the scalp above the right ear. He had occasional headaches, and the intermittent periods of soreness. The general physical examination was negative at that time. The pulse, respiration and temperature were normal at each examination. The laboratory examinations showed no positive findings. The red, white and differential blood counts were normal. Urinalysis and blood chemistry were within normal limits. Wassermann and Kahn tests were negative. Examination of the spinal fluid showed no significant findings. The Wassermann and colloidal gold reactions were negative. Cell count 4. Globulin negative.

Further roentgen studies were made at about two-month intervals up to March, 1937. At each examination there was a definite increase in size of the skull defect with no apparent change in the symptoms. The area of the skull lesion then measured 12.0 cm. in its anteroposterior diameter and 8.3 cm. in its greatest vertical diameter (Figs. 3 and 4). There was slight evidence of bone regeneration in the anterior portion. At that time we decided to use roentgen therapy. If the condition was due to xanthoma there should be a definite response to radiation therapy. If it was due to a low-grade nonspecific osteomyelitis, a condition we had strongly considered, there was a chance of getting some beneficial effect. Certainly it seemed that there was no contraindication to this form of treatment. The first series of treatments was in March, 1937. Films of the skull in May and June for the first time showed no change in the size of the defect. There was slight further bone regeneration in the anterior portion. A second series of roentgen treatments was given in the period of June 19 to August 20, 1937. Roentgen examination in August showed very definite recalcification throughout the entire skull defect, with no extension of the lesion. In November, 1937, the bone regeneration was still more pronounced, with no further spread of the defect (Fig. 5). By October, 1938, a year and half after the first series of roentgen treatments, there was almost complete filling in of the involved area (Fig. 6). The puffy swelling in the scalp, over the bone lesion, was noted on examination of the patient in August, 1936. This changed very little between then and March, 1937. If anything, there was a slight increase in size. The swelling showed no further change until about the first of August, when it

Fig. 5. Skull defect in November, 1937, about eight months after roentgen therapy was begun. There is considerable bone regeneration, and no further extension of the destructive process.

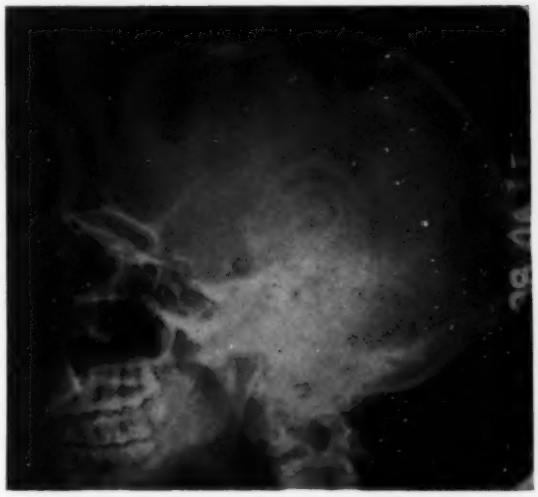

Fig. 6. Skull defect in October, 1938, nineteen months after first series of roentgen treatments. Bone regeneration has almost completely filled in the involved area. No extension of the destructive process after roentgen therapy was started.

rapidly diminished in size and disappeared completely. This was while the second series of roentgen treatments was being given. After the swelling disappeared, the entire area of the bone lesion could be felt as an irregular granular surface. This patient has worked at his regular duties throughout the entire period of observation from April, 1935, up to the present, with the exception of a period of time in the latter part of 1936 when he was hospitalized for closer observation. He has shown no other skeletal lesions, and has shown none of the other symptoms of Schüller-Christian's disease.

As regards treatment, radiation therapy is the treatment of choice. Glandular and dietetic therapy have been tried with little success. Rowland used a low fat diet and thought he obtained some benefit in one of his cases. However, the treatment was complicated by the use of thyroid and pituitary extracts. Sosman tried diet therapy without success. The glandular extracts and solutions have been used with little success. The diabetes insipidus can be controlled with solution of pituitary. Insulin is also of some benefit in that it stimulates the appetite and thus favorably influences the weight and strength of the patient. Endocrine therapy has shown no effect upon the bone lesions.

Radiation therapy, with roentgen rays or radium, offers the only known means of effectively treating this type of bone lesion. Exophthalmos when present is not reduced by irradiation. Treatment of the pituitary gland with roentgen rays has shown remarkable results in its effect on the diabetes insipidus and the arrest in growth. The effect on bone lesions is even more spectacular. Our case showed a steady progressive enlargement of the cranial defect up to March, 1937, the time roentgen therapy was begun. From that time on there was no further spread of the lesion, and there has been a steady filling in of bone throughout the area.

This case is believed to be of special interest in that it shows only one of the characteristic symptoms of this disease, the cranial defect. The diagnosis is confirmed by its prompt response to radiation therapy.

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Vol. 44, No. 3

THE EFFECT OF FRACTIONAL ROENTGEN IRRADIATION ON SEVERAL GROUPS OF INOPERABLE TUMORS*

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COUTARD'S method for irradiation by means of protracted and fractional doses undoubtedly introduced a new period in the radiotherapy of cancer. The method has its difficulties: daily treatment, the long period of treatment, the severe skin reactions and the after treatment necessitated thereby, as well as the not completely evaded danger of late damage. Some successes with this method in the case of tumors, the treatment of which by older techniques or with radium seemed hopeless, taught me the special importance of this method of treatment. Especially is this so in very advanced or widespread tumors, or in cancers which through their location within the body or in other inaccessible regions of the body offer no hope of a successful treatment by irradiation.

I would like to prove the value of fractional irradiation by a series of cases which are characteristic both as to indication and as to the results that can be obtained. I abandoned the method of protracting the treatment, for reasons into which I cannot go in this short space of time. I must also ask you to look upon the case histories as incomplete since I am able only to indicate the most essential points.

Mammary Cancer

CASE 1. (Fig. 1.) Female, aged forty-one, with a solid node in the right breast. Treated periodically for one and a half years; the tumor was now completely inoperable. The right breast was a rock-like, red, immovable node. Large regional lymph nodes. On the left side and above the breast there were two large skin metastases; an erysipelas carcinomatosum extended from the right lower quadrant.

Radiation therapy was given. In all these cases the primary tumor received a daily dose of 185 r (in air) per field. In many cases the first treatment consisted of 3,600 r per field. The areas of the tumor which were not reached by this irradiation, for example the regional lymph nodes, outlying skin metastases, and tumors of the other breast, were treated according to conditions either by roentgen rays or radium, since it is impossible to irradiate more than one focus fractionally at the same time. This case received a total of 5,000 r. Final result: the skin and lymph node metastases disappeared completely as did the carcinomatous erysipelas. The affected breast became soft, small and the skin of normal texture; not cancerous to palpation. The patient died six months later from cardiac failure.

FIG. 1. Case 1. Carcinoma of the breast with numerous small and large skin metastases.

* Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

FIG. 2. Case II. Ulcerating carcinoma of the breast with lenticular metastases. Before treatment.

FIG. 3. Case II. After treatment. Central part not entirely healed.

CASE II. Female, aged forty-three. Two years ago a tumor appeared in the right breast and one year ago in the left breast. Both sides were untreated. On the left at the beginning of treatment the breast was stony hard with a bleeding ulcer almost the size of the palm of a hand (Fig. 2). Ribbon-like carcinomatous erysipelas of the lower and outer quadrant of the breast. There was bilateral involvement of the axillary and supraclavicular lymph nodes. The ulcerating tumor received 9,000 r primary radiation.

FIG. 4. Case III. Carcinomatous mastitis with metastatic nodes. Before treatment

After three weeks the erysipelas disappeared; after eight weeks the ulcer granulated and epithelialized. The breast is soft, small and completely covered by epidermis (Fig. 3). The patient is alive after one year without recurrence.

CASE III. Female, aged sixty. The left breast was transformed into an enormous, hard, bluish-red tumor. There were hard skin metastases near the left upper quadrant (Fig. 4). On the right there were lenticular metastases and widespread carcinomatous erysipelas. Irradiation was given with 5,600 r (in air). This was well borne despite a severe diabetes. The erysipelas on the right was given 5,120 r.

Result: the erysipelas disappeared; both breasts are pendulous, small, without residual tumor (Fig. 5). The patient is alive but still has the lenticular skin metastases and a metastasis of the spinal column.

Case iv. Female, aged seventy-five. The right breast had a plum-sized knotty tumor with an ingrown nipple. The left breast was shrunken and transformed into a large neoplastic crater (Fig. 6). There was profuse bleeding from the tumor. Fractional irradiation

Fig. 5. Case iii. After treatment. Breast soft, nodules disappeared. Residual skin changes.

of the ulcer was carried out with 4,818 r (in air). The tumor healed and fibrosed well (Fig. 7).

Cancer of the Stomach

Case v. Female, aged fifty-nine. She complained of pain and nausea, loss of weight of 88 pounds, resistance in the area of the stomach. No acid; stool positive for blood. In the roentgenogram there was an irregular arrangement of the rugae with wart-like indentations. There was a defect above the angle; small irregularities of the curvatures at the antrum. With complete filling there was a sharp defect above the angle. The greater curvature near the antrum was fixed (Fig. 8). Radiation ther-

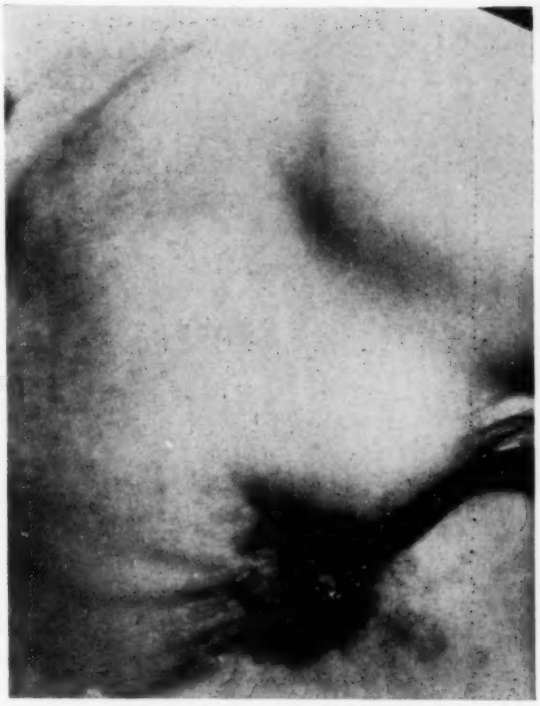

Fig. 6. Case iv. Scirrhous ulcerated carcinoma of the breast. Before treatment.

Fig. 7. Case iv. After treatment. Small, centrally indented scar.

apy was given—forty-two treatments using three fields and totalling 7,350 r (in air). After seven weeks she was free of pain, appetite improved, and she was symptom-free after six months. There was a gain in weight of 6 pounds. The roentgenoscopic examination showed the rugae to be normal; with complete filling the contours were smooth and movable. The patient is alive after more than two years. The roentgenogram showed a normal stomach (Fig. 9).

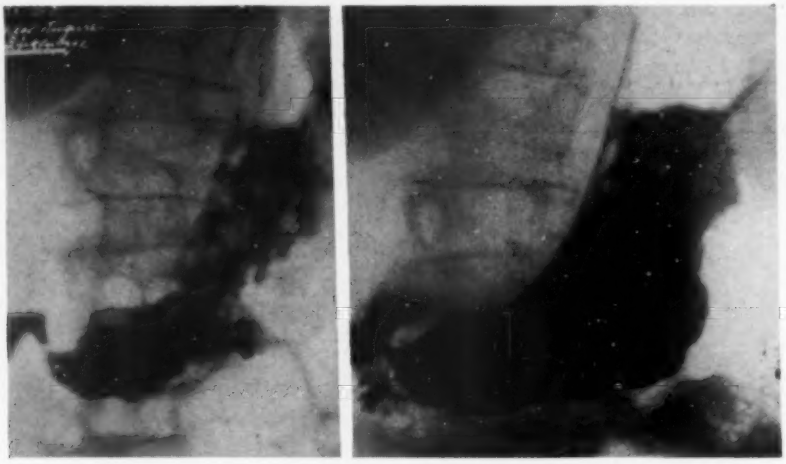

FIG. 8. Case v. Extensive carcinoma of the stomach. Note rugae after complete filling of stomach with contrast medium, also large defect on large curvature. Before treatment.

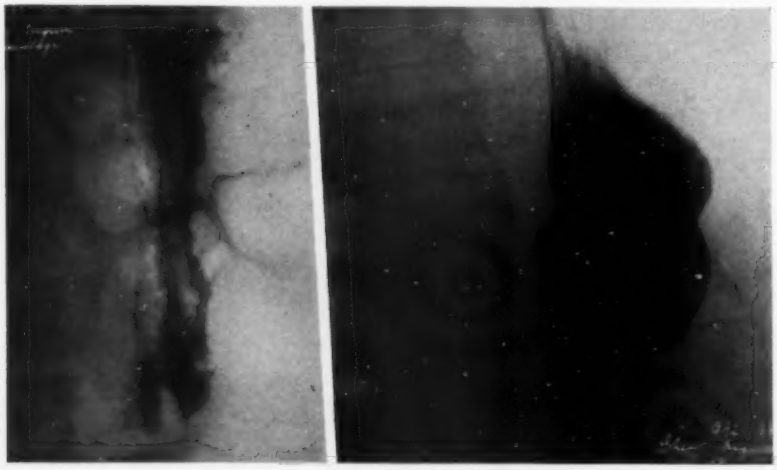

FIG. 9. Case v. After treatment. Normal rugae and contour; good peristalsis.

CASE VI. Female, aged fifty-two, with complaint of gastric pains, loss of weight, large palpable tumor. Laparotomy revealed an inoperable growth. Shortly before operation roentgen examination showed disarranged rugae in the upper fundus and an irregular fringe-like appearance of the greater curvatures; with complete filling there was an irregular indentation of the lesser curvature and a sharp indentation of the greater curvature (Fig. 10). At the beginning of treatment the patient was bedridden and refused nourishment. Roentgen irradiation consisted of fifty treatments over four fields, totalling 8,750 r. After seven weeks there was a gain in weight of 3 pounds and an amazing feeling of well-being. Six months later the patient was symptom-free, had gained 10 pounds in weight and the tumor was not pal-

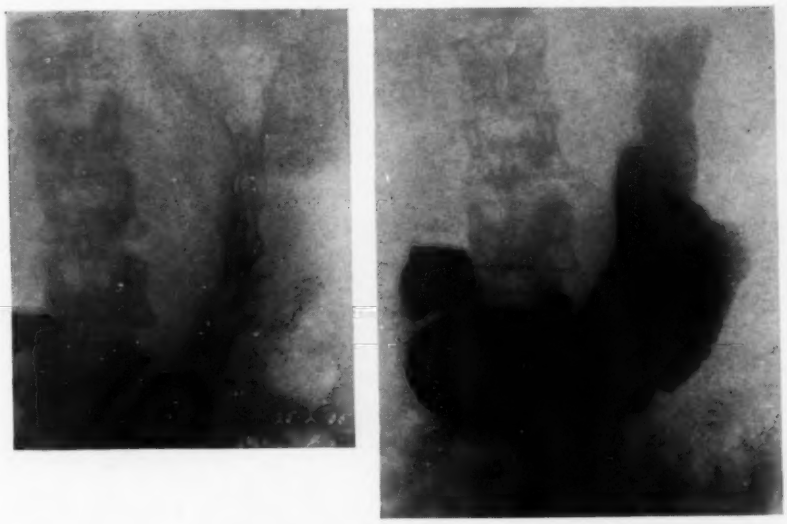

Fig. 10. Case vi. Extensive gastric tumor with destruction of mucosa and filling defect. Before treatment.

pable. Roentgenologically there were no filling defects and the rugae appeared normal (Fig. 11). There were the same normal findings after one year. The patient had no signs or symptoms for one and a half years. She died two years later from metastases.

Case vii. Female, aged fifty-nine. There were anorexia, loss of weight and palpable tumor in the stomach region for six months. Blood in the stool, hemoglobin 25 per cent, cachexia and edema. The roentgenogram showed irregularities of the rugae with large smooth areas. Behind the angle the barium was broken up into a serrated mass and limited to a narrow central pathway. There was a total defect of the antrum; large three hour residue (Fig. 12). Fifty radiation treatments were given over three fields totalling 8,750 r. In three months her general condition was good, there was a gain in weight of 7 pounds and she was ambulatory. Roentgen examination showed that the antrum was reconstituted and had smooth and movable contours (Fig. 13). Radiation therapy was repeated in four and eleven months (2,400 r). Patient is alive after one and a half years, her general condition is good, with occasional feeling of fullness in the epigastrium.

Cancer of the Bladder

Case viii. Male, aged fifty-eight. For two years the patient had bladder symptoms. Two months ago dysuria and lately anuria. Blood in the urine. Cystoscopy showed a papillary

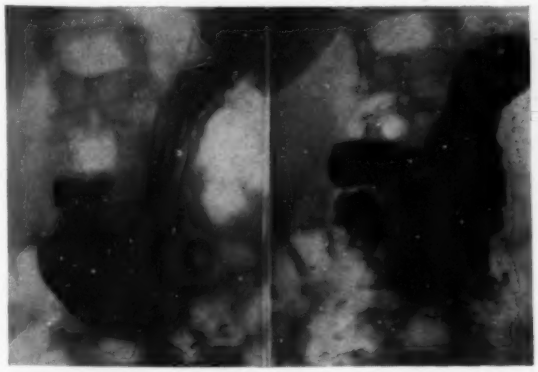

Fig. 11. Case vi. After treatment. Contour and rugae normal.

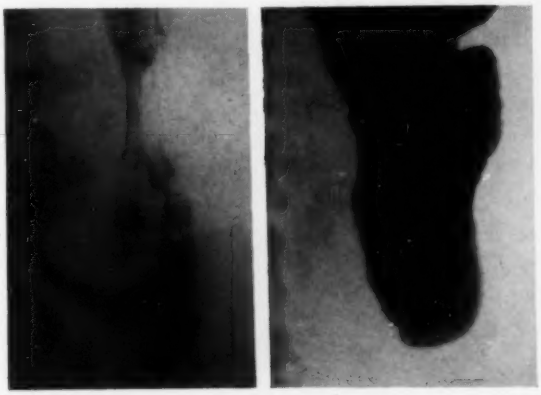

Fig. 12. Case vii. Gastric tumor causing large filling defect in antrum.

tumor occupying the entire floor of the bladder. Histologically it was carcinoma. Electrocoagulation for six months could not stop the bleeding. Radiation therapy was given in twenty-five treatments over two lateral fields, totalling 4,776 r. After four months there were no bladder symptoms; the urine was completely normal. The bladder capacity had increased. The patient is alive and symptom-free after two years.

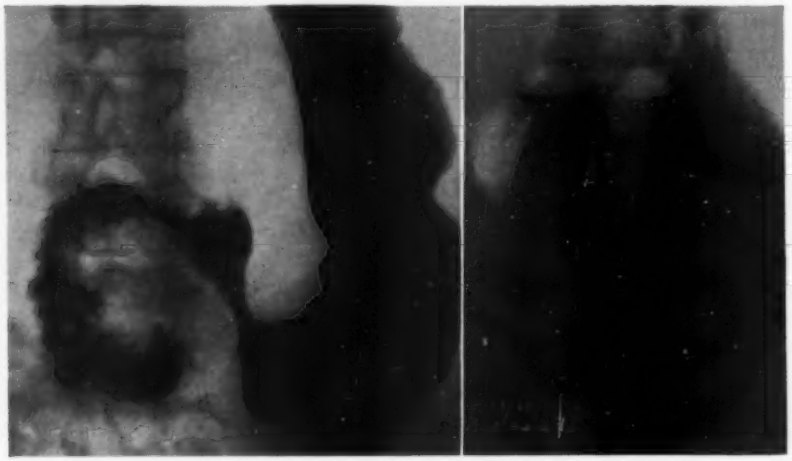

FIG. 13. Case VII. After treatment. Note filling of antrum.

CASE IX. Female, aged sixty-seven. Bladder symptoms for one year. Blood in the urine. Cystoscopically the tumor was partly cystic, partly ulcerating and degenerating. Twenty-nine roentgen treatments were given over three fields, 7,448 r. After three months there was subjective wellbeing, objective disappearance of the tumor. After nine months she was symptom-free. Cystoscopy normal. Small recurrence in one year. Irradiation was repeated (3,850 r). After two years she was symptom-free as far as the bladder was concerned. There is a central necrosis of the skin.

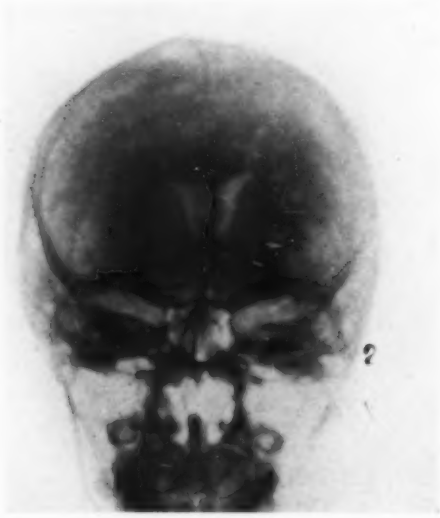

FIG. 14. Case X. Brain tumor on right. Compression of right ventricle after air injection.

Brain Tumors

CASE X. Female, aged twenty-three. Attacks of dizziness and cramps. Clinically the tumor was localized to the right precentral region. Encephalography showed the compression of the root of the lateral ventricle (Fig. 14). Trephining for decompression. A widely infiltrating tumor of the right precentral region was found. Biopsy showed it to be a glioblastoma multiforme. Radiation therapy was given over five fields, three over the tumor, two from the sides, thirty-five treatments, 9,660 r. Treatment was repeated three times, totalling 32,649 r. Patient is alive after two years and ten months. Free of attacks, works as a stenographer, rides a bicycle and swims.

CASE XI. Female, aged twenty-nine. Sudden onset of epileptiform attacks which became more frequent and could be localized as originating in the left precentral region. Roentgenograms showed signs of cerebral pressure; encephalography revealed compression of the left lateral ventricle from above, and incomplete

ventricular filling on the right (Fig. 15). Operation showed an infiltrating tumor on the left precentral region involving the corpus callosum. Biopsy showed a glioblastoma multiforme. Twenty-nine roentgen treatments were given, four fields, 8,000 r. Repeated after six and eight months. There was a total of ninety-one treatments and a total dose of 22,800 r. The patient is alive after three years and does light housework. Infrequent mild attacks.

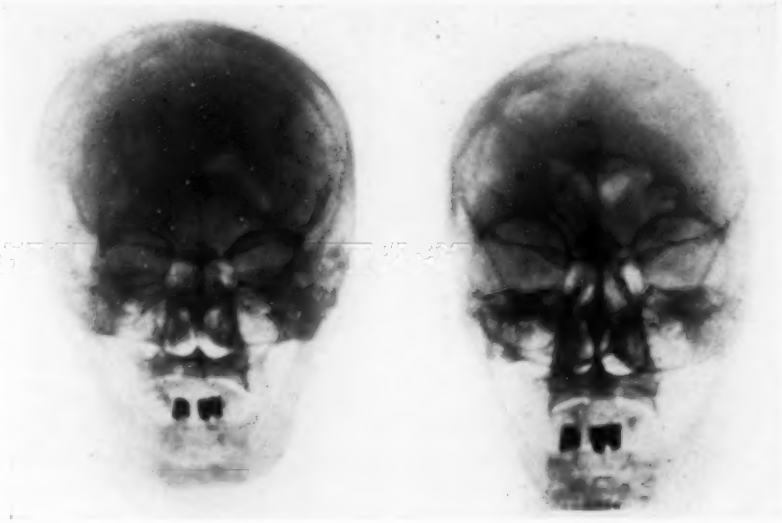

FIG. 15. Case XI. Tumor of the left brain and the corpus callosum. Compression of the left ventricle; configuration of the right ventricle.

CASE XII. Male, aged thirty-seven. For three years he had attacks of dizziness, nausea, later epileptiform convulsions. Towards the last, stupor and high fever. Bilateral papilledema. Roentgenologically there were signs of increased intracranial pressure. Trephining revealed a red colored frontal brain solidly infiltrated. Biopsy showed an unclassified tumor of the glioma type. Irradiation was given over four fields, forty-seven treatments, 11,280 r. After thirteen months the irradiation was repeated. Total dosage, 16,550 r. Patient is alive after two years and four months. Good general condition. Headaches and papilledema receding. He is at work as a peddler.

COMMENT

Out of a total of over 50 cancers, among which there were 12 gastric and 14 brain tumors, 12 cases were selected not because they gave the best results but because they were of the most widespread type and were located in regions especially difficult of approach. It has been shown that with good technique one can forego the protracted dosage and achieve in many cases gratifying and unexpected results locally as well as in relation to prolongation of life. On the basis of this experience, one is undoubtedly justified in having the patient undergo the discomfort of the treatment, and in giving them hope. Considering the types of cases described above, it seems that the indication for irradiation in respect to the localization of cancers should be widened to extend beyond the tumors usually irradiated (of the parotid, rectum, uterus, ovary, mediastinum and lung). This also refers to hopeless cases with very widespread involvement which often show astounding local and general improvement.

In the cases of mammary carcinoma, the good results are convincing since they are visible. In gastric cancer one relies upon the general status, palpation and the disappearance of blood from the stool as signs of the recession of the tumor. The best proof is offered by roentgen examination, namely the disappearance of filling defects and the return of mobility and often normal rugae,

especially if these signs coincide with general improvement. One has to assume that infiltrations disappear and that new mucosa is developed. An analogy is found in the cystoscopic examinations of the bladder tumors where the healing of the mucosa could be demonstrated without a doubt. Also in cases of brain tumor one has to believe in the result when neurological signs and papilledema disappear, when attacks cease, and when the patients become capable of performing work, as could be seen in a few of our cases.

The unavoidable changes (epithelitis sicca and exudativa) heal at all ages. Our youngest patient (aged seven) with carcinoma of the thymus, as well as the oldest patients (aged seventy-five with mammary carcinoma, and seventy-seven with parotid carcinoma) grew normal skin again. The skin of the face is the most resistant and heals the most rapidly. On the breast and on the abdomen there may be large denuded areas but after sufficient time there is again delicate new skin. The lower abdomen is the most sensitive area and here we have seen several telangiectases and a central ulcer. Epithelial tumors in this region also do not heal well.

The dose was varied; 4,000–5,000 r was sufficient for a pharyngeal or laryngeal carcinoma. We gave 5,000–9,000 r in mammary and gastric carcinoma. There was only moderate reaction and no general reaction. A number of brain tumors also received 5,000–9,000 r. In these cases the skin reactions were very moderate. Depilation did not occur in every case. It was most surprising that these reactions were not more pronounced since we gave in these cases 10,000–11,000 r in one series and the total amounts were 16,500–23,000 and over 32,000 r. Here also there was never an epithelitis, and after 25,000 r in our patient aged twenty-three the hair began to grow again. We use these enormous doses because of the experience that glioblastomata did not show any measurable improvement even after irradiation. However, when one sees, from our series of brain tumors, that those patients who refused a repetition of the dosage are all dead, and that those who received three very large doses are alive for years and capable of work, then this seems to be the method which we have to use. A smaller dose may be sufficient for other tumors but even here our results show that the fractional method of irradiation for any type of carcinoma, in any location, no matter how widespread it may be, is at present the method of choice.

Vol. 44, No. 3

THE DEBT OF RADIOLOGY TO THE THOMSONS AND THE THOMPSONS, PHYSICISTS AND ENGINEERS

AN HISTORICAL MEMOIR

By PERCY BROWN, M.D.
Historian of the American Roentgen Ray Society

It is fitting that the radiologists of the world . . . should acknowledge the debt of radiology to the physicists, and should express to them their pride and satisfaction in the close relationship that exists today between physicists and radiologists. . . .*

IN THE fifth century B.C., the etymological derivation of our modern word "history" was used by the Ancients to denote inquiry, research, investigation—not narrative. The American authority Shotwell reminds us that not until two hundred years later did the *historikos*, the reciter of stories, supersede the *historeōn*, the seeker after knowledge. In the hypertense scientific atmosphere of modern times, the true historian of the birth and growth of a science, bearing in mind this chronological transition, should strive to adhere to the original signification of this noun and to apply his functional effort in the direction of investigation, with its implication of care and detailed thoroughness, rather than toward literary presentation in which rhetorical form might, conceivably, obscure or even supplant historical accuracy. Thus will he keep his status pure, for "revelation no longer appeals to scientific minds as a source of knowledge. Experience, on the other hand, is history."

No historian of scientific progress need lack for research material if he but choose to investigate. The fund of human experience in this field, upon which he may freely draw, is never exhausted as a result of the first quest. But if he be carried away by the obvious brilliance of some great discovery, for instance, and become enmeshed in the fascinations of its mere rhetorical narration, he is by way of losing the invaluable fruits of deeper historical inquiry—the facts surrounding certain antecedent achievements that may have been of signal importance as facilitants to the epochal event.

These contributory accomplishments usually furnish a wealth of material for the historian in the form of factual paving-blocks to support the march of progress. In reviewing the background of the steam engine or the more modern steam turbine, for example, we recall most readily, perhaps, the names of James Watt, of Parsons or of De Laval. But only thorough historical research can resurrect the physical details of the "aeolipile," clearly a primitive form of steam reaction turbine, described by Hero of Alexandria in 130 B.C., or can continue to carry us forward, by the most interesting historical progression, to the comparatively modern attainments of Watt and of others subsequent to his time. Again, the mere "teller of tales" would probably relate to us only the romance of the great discovery of Graham Bell, which culminated at the urgent moment of his immortalized entreaty, "Watson, come here, I want you," but it requires the pains of the research historian to compel our realization of its background: the years of Bell's tireless application of his clearly inherited gifts as a patient instructor of elocution and speech articulation, his investigations on the subject of human deafness, his education of deaf-mute children in speech and his more formal teaching of "vocal physiology"—episodes in the approach to the ultimate product of his genius, the electric speaking telephone.

That the radiologist of today is familiar

* Christie, A. C. President's Address, Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

with the many contributions to pure science within the domain of electrophysics which, in accordance with the same chronological pattern, were forerunners of the discovery of x-rays, is due in large measure to the labors of annalists who have happened to be at once historians and physicists. Their records inform us that the wide-spread investigation on which these contributions were based had long concerned itself with the problem of interelectrodal discharges in atmospheric air and through gases at all pressures and in various degrees of rarefaction, from the remote day of Abbé Nollet's "electrical egg," the evacuated glass vessel by means of which were held spellbound the large audiences of this facile teacher from whose rostrum and pen proceeded the rudimental concept that electricity is a fluid and an inflammable one; from the day of the versatile Sir Humphrey Davy and his voltaic arc in open air and of the repeated investigations of the prolific Michael Faraday which revived the flagging experimentation with respect to high-tension electrical discharges through rarefied gases; from the subsequent era of somewhat less frail discharge-tubes capable of higher degrees of evacuation—an era that created names now famous, among them those of Geissler and of Sprengel, that of the brilliant Heinrich Hertz, of Hittorf the pupil of Julius Plücker, of Lenard, once the assistant of Hertz, and the name of William Crookes. The observations of Hertz, Hittorf, Lenard and Crookes, in connection with the behavior of the negative radiation-stream from the cathode, both within and without the discharge-chamber and under all influences of temperature, tube-wall composition and magnetism, bring the research of the historian close to the immediate background of the roentgen rays.

At this point, however, the hitherto even tenor of his chronicle becomes interrupted, and in dealing with the unquestioned basic progress of scientific investigation concerning the discharge-tube since Abbé Nollet and his time, the historian is forced to record the existence of an early and apparently insurmountable impediment thereto which obtained for many years. The nature of this difficulty was indicated in the words of the annoyed yet undismayed Wilhelm Hittorf in 1869: "The darkest part of the science of electricity today is incontrovertibly the process by which current is conducted through gases." This process was then, and for twenty-six years to come, possible of achievement only by utilizing currents of very high potential, or by employing gases so hot as to be actually flaming. Moreover, under these necessary conditions the matter of accurate mensuration became a most difficult one. Hittorf shared with the natural philosophers of a contemporaneous scientific world this sense of frustration, and yet it imposed upon this splendid scientist still another personal tribulation to be added to those he had already to endure.

As soon as the significance of Röntgen's *Preliminary Communication* of late December, 1895, became apparent to the discerning apperception of such scientists, the usually placid atmosphere of every important physical laboratory the world over became vibrant with a quickening of the investigative spirit, and ardent inquiry was instituted at once. Research already in hand was for the time being set aside; laboratory machine-shops were impressed into service in order promptly to reproduce the apparatus with which Röntgen's discovery was effected. Its primary factors were simple enough—merely the Ruhmkorff induction coil, the Lenard and Hittorf-Crookes vacuum tubes, the paper screen coated with barium platino-cyanid, as well as the sensitized photographic plates to be found in daily use in most laboratories.

In view of this ancient problem of theirs regarding electrical discharges through gases, it is easy to understand such a reaction on the part of physicists to the epochal report from the Physical Institute of the University of Würzburg. The properties of the x-rays as enumerated and described by Röntgen furnished the hopeful expectation of a new and powerful experimental agent.

One of the illustrious subjects of this brief memoir, Sir J. J. Thomson, has commented reminiscently on the immediately ensuing activities at the Cavendish Laboratory of Cambridge University. He describes typically the keen curiosity of the moment:

> It was a most fortunate coincidence [he writes] that the advent of research students at the Cavendish Laboratory came at the same time as the announcement by Röntgen of his discovery of the x-rays.* I had a copy of his apparatus made and set up at the Laboratory, and the first thing I did with it was to see what effect the passage of the rays through a gas would produce on its electrical properties. . . .

The effect sought by Thomson proved to be a most satisfying one. To have found, as he remarked years later in retrospection, a controllable and convenient method, through this discovery of Röntgen's, of producing conductivity in gases by which they seem to become true gaseous electrolytes, and by means of this increased conductivity to obtain the accurate measurements almost impossible with either high electromotive force or flaming gases, "was like coming into smooth water after long buffeting by heavy seas."

Of the English-speaking scientists who at the time of Röntgen's announcement were occupied with problems of electrophysics, contemporaneous literature relates that the research of at least five experimenters was concerned in variant degree with this very matter of electrical discharges in gases under relative compression or exhaustion. Probably many more were similarly engaged, but it is a noteworthy coincidence that each individual of this group of five, although not immediately related by ties of blood, bore the name of the great family of Thomson or Thompson, an ancient stock of Scottish or Northwestern English distribution. It will be found that this family has given generously of its genius to the development of Science, Theology, the Law or the Arts in both Britain and America. A remarkable concentration of this liberality was manifested in the calibre of these five physicists and engineers who played a part so essential to the orderly and rational evolvement of Radiology. To them, as well as to all such as they, is her debt outstanding.

FIG. 1. Sir J. J. Thomson. (Painting by Fiddes Watt.) (Courtesy The Royal Society, London.)

JOSEPH JOHN THOMSON (1856—)†

Sir J. J. Thomson—for thus is his name commonly recorded in scientific history—is one of a group of the most renowned mathematicians, physicists and engineers that Cambridge University has produced, which included also, in their day, such scholars as Routh, Clerk-Maxwell, Lord Rayleigh, Lord Kelvin, Sir George Stokes and Schuster. Autobiographically he asserts that he became a physicist by mere accident. Born near Manchester in 1856,

* In 1895 a regulation was established by which graduates of other Universities were admitted to Cambridge as "research students."

† As this article goes to press, the death of Sir Joseph J. Thomson is announced on August 30, 1940, at Cambridge, England.

for him the career of an engineer was intended, and only by the length of a waiting-list for apprentices was he deterred from this form of practical training to enter Owens College, Manchester, as a member of its engineering course, at the age of fourteen years. At the end of his second year there, his education in this special field was interrupted by the death of his father and the consequent burden upon his mother entailed by the large premium required for him to become an apprentice, the only avenue to the profession in those days. With the aid of a scholarship and an essay prize, however, Thomson was enabled not only to complete his course in engineering but to take an added year in mathematics and physics as preparation for an entrance scholarship at Trinity College, Cambridge, in 1876. With Trinity he has been connected, as student, Fellow and Master, for almost sixty-five years.

After taking his Bachelor's degree from Cambridge, Thomson taught mathematics privately and at the now non-existent Cavendish College for younger students. Within two years he was elected to an Assistant Lecturership in mathematics at Trinity, which in his case amounted to eighteen hours a week of teaching and gave him little time for research. Thomson was a successful young instructor and consequently successful, on his own behalf, in his examination for a Fellowship.

He was created a Fellow of Trinity College in 1880. This gave him the desired opportunity for research, and as he had been attracted by Crookes's experiments with cathode rays, he began at the Cavendish Laboratory a mathematical investigation on moving charges of electricity. His results were published in 1881. The following year Thomson won the Adams prize with the title "A Treatise on the Motion of Vortex Rings." In 1883 he became University Lecturer in Physics and in this capacity taught electrostatics and electromagnetism during that academic year. In early 1884 Thomson was elected a Fellow of the Royal Society and in December of the same year he succeeded Lord Rayleigh as Cavendish Professor of Experimental Physics. In due course he developed the Cavendish Laboratory into a great research institution which has attracted workers from many countries. Among these research students who have since attained fame as physicists were Wilson, Rutherford, Townsend, Richardson, McClelland and Kaye.

In 1883 came the first publication of Thomson's work on the passage of electricity through gases; from that time until 1895 he carried out, or supervised in the hands of others, experimentation dealing with such subjects as the dissociation of bromine and of iodine (1885), the changes produced in nitrogen (1886), the production of ozone (1886), and the dielectric strength of mixed gases. Following these researches came his notable work on discharge through hot gases (1890) and electrodeless discharge (1891).

Hampered as he was through these years by the particular difficulties which this long research entailed, it is small wonder that Sir J. J. Thomson hailed with joy, as has been said, the new and welcome manifestations exhibited by these gases, under all pressures and temperatures, in the presence of roentgen rays. Early in 1896 his interest became focused on the problem of electrical discharges produced by roentgen rays and a few months later he investigated the effect on dielectrics, especially that of electrical leakage, by roentgen rays traversing them; also, he subsequently arrived at the quantitative determination of the roentgen rays.

As in the case of all kindred institutions of learning during the public excitement following Röntgen's discovery, the academic atmosphere of pure physics at the Cavendish Laboratory could not completely exclude a certain collateral inquisitiveness as to the more practical application of the roentgen rays. Indeed, a scheme was soon organized under which medical men of the surrounding district were invited to bring in their patients with broken

bones in order that the exact results of their surgical intervention might be observed. Professor Thomson, in his *Recollections and Reflections*, tells in humorous vein of how, on one occasion, the laboratory assistant who made the "diagnostic" exposure, finding by this means that these results were not of the happiest, hastily left the scene of the immediately ensuing conference between surgeon and patient. On being asked the reason for his hurried retreat, he replied, "I came away because I thought the doctor would not like to have me hear what Mr. Blank was saying to him after he saw the photograph."

Aside from his many years of work on the conduction of electricity through gases, one of Thomson's principal contributions to the progress of experimental physics was his determination of the charge and mass of the electron (1897–1899) and of the number of electrons in the atom (1904) by measuring the scattering of roentgen rays when passing through a gas. From the former investigation he concluded, first, that atoms are not indivisible, for negatively electrified particles can be torn from them by the action of electrical forces, by the impact of rapidly moving atoms, by ultraviolet light or by heat; second, that these particles are all of the same mass and carry the same charge of negative electricity from whatever kind of atom they may be derived, and that they are a constituent of all atoms; and third, that the mass of these particles is less than one-thousandth part of the mass of an atom of hydrogen. Thomson first gave the name of *corpuscle* to these particles, but they have been subsequently called *electrons*.

Especially since the beginning of this century many highly deserved honors have descended upon Sir J. J. Thomson in addition to the Order of Knighthood in 1908. He received the Nobel Prize for Physics in 1906 and the Order of Merit six years later. Toward the close of the first World War he became Master of Trinity College. Among other decorations have been the Royal and the Hughes Medals of The Royal Society, the Franklin Medal, and also the Hodgkin's Medal of the Smithsonian Institution.

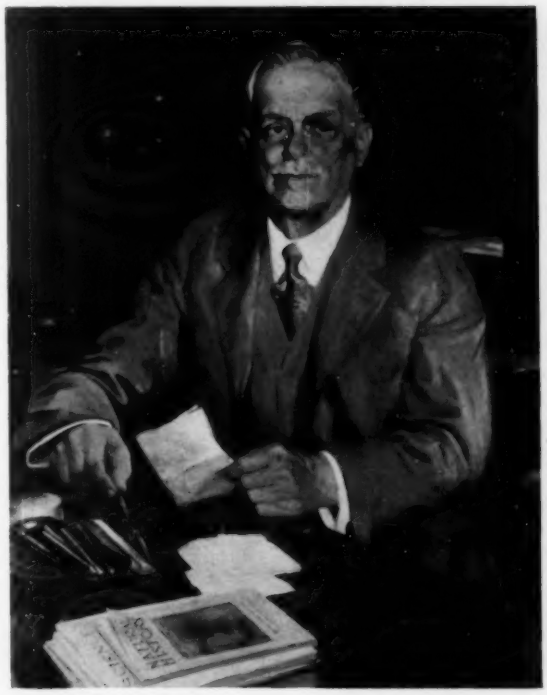

Fig. 2. Elihu Thomson. (Courtesy General Electric X-Ray Corporation.)

Thus is afforded an inadequate glimpse of some of the accomplishments of this brilliant investigator and teacher, whose earlier research on the discharge-tube and its behavior under all circumstances, together with that of Hittorf, Crookes and others, ultimately laid upon Röntgen's laboratory table what proved to be the frail instruments of his great discovery.

Elihu Thomson (1853–1937)

Elihu Thomson, although British-born in Manchester, England, emigrated with his parents to the United States at the youthful age of five years. He received his early education at the Boys' Central High School of Philadelphia. Soon after his graduation there he was appointed an instructor in chemistry and mechanics, later an assistant professor at the age of twenty years and in 1876, at twenty-three, profes-

sor! In addition to his regular teaching at the High School, he gave popular lectures in mechanics and chemistry at the Franklin Institute of Philadelphia.

Evolved in conjunction with his teaching and his subsequent activities in applied electrodynamics, many of Thomson's contributions to the elaboration of electrophysics and to the development of electrical engineering were years in advance of the moment of their common acceptance and application. Although it is recorded that his first great contribution to electrical engineering was his three-coil direct-current dynamo (1879), we do well to resist the general tendency to forget the fact of his successful demonstration in 1875, while he was yet a young teacher and which preceded the discovery by Hertz based on Clerk-Maxwell's theory, of the progressive propagation of electromagnetic action through space.

A year or two following the development of his arc dynamo, Thomson devised a method, now generally used in connection with large currents, of magnetically controlled automatic circuit-breaking, whereby uncertain action and the fire-hazard from large arcs are obviated. Also during this early period of his career he produced the now universally employed system of transmitting and distributing high-voltage electric power for low-voltage requirements by means of step-down transformers. In addition he patented, as another safety measure, a method of grounding the secondary coil of these transformers, dedicating this patent, furthermore, in the name of the public safety, to common use without restriction tending to limit its general availability. In order further to increase the efficiency of transformers, it was Thomson who first utilized oil in them for purposes of cooling and more perfect insulation (1887–1889).

Besides these manifestations of his scientific calibre, two more of Elihu Thomson's early achievements must be noted by the chronicler who would attempt to indicate briefly the development of his inventive genius. Note must be made of his process of electric welding wherein the metallic union is effected by fusion from the heat developed by the resistance at the point of contact, as well as of his system of utilizing dynamical repulsion between the primary and secondary windings, as exemplified in the small alternating current, single-phase, repulsion-induction motors now in general use. Even more commonly useful wherever electrical power is supplied and consumed is the recording watt-meter, the prototype of which was Thomson's invention.

By these few examples of his productiveness as an engineer and an inventor an accurate estimate of his usefulness may be formed. He was the holder of over seven hundred American patents which were concerned with the application of scores of engineering principles.

It may be fairly stated that of the small group of scientists who are herein the subjects of brief biography, the name of Elihu Thomson, from an historical standpoint, is the one most practically connected with the very early development of the science of roentgenology. His early experience in the teaching of chemistry, and the opportunities thus offered for striking demonstrations at the lecture-table, probably stimulated his natural interest in the physics of the discharge-tube with especial reference to gases, but his later and very practical contact with the development of the incandescent electric lamp during the years following 1878 may well have been the influence that guided his attention to the general subject of vacua.

Many years before the event of Röntgen's discovery, Thomson had obtained a number of vacuum tubes of the Hittorf-Crookes type, with which he demonstrated the properties of cathodal radiation previously elaborated by Crookes and Lenard. Early in 1896, with the information afforded by Röntgen's earlier *Communications*, he proceeded to determine the best form of vacuum-tube for the propagation of x-rays. This done, he duplicated this

tube, making certain modifications with a view to standardization. One modification was a double-focus tube to be used with alternating current properly stepped up.

In this way did Elihu Thomson commence a course of practical investigations with roentgen rays that has raised his name to an important position in roentgenological history. He found that roentgenographic impressions could be very many times manifolded on layers of "bromide paper." He developed the technique of producing and examining stereoroentgenograms and suggested the possibility of stereoroentgenoscopic procedures. He established the value of the concave cathode. He demonstrated the existence and sources of secondary and tertiary radiations that were the unwelcome accompaniment of gas-tube excitation and often the despair of the early "radiographer."

Physical conditions somewhat akin to these untoward phenomena gave rise to an intense controversy as to the exact cause of the deleterious effects upon the skin which were becoming evident among those occupied with the manufacture and operation of roentgen-ray apparatus—physicians, technicians and artisans. Thomson set himself to determine, by deliberate experimentation on his own person, the source of these reactions. His injuries were definite, but happily without permanent effect. By this self-abnegating act, performed in the true spirit of scientific inquiry, he established the fact that such bodily mutilation is due, not to the effect of the static field around the discharge-chamber, nor to cathode rays or ultraviolet rays produced simultaneously, nor to gaseous chemical products generated in the tissues exposed, nor to any influence except the roentgen rays themselves. Likewise was dispelled the total misconception that a Crookes tube energized by a "static machine" propagated radiation much less noxious in character than one operated from an induction-coil.

Thomson reported this experiment in the *American X-ray Journal* and in the *Electrical Engineer*. Space will not allow of its quotation here, but it has been variously described in the roentgenological literature within the past decade. Nor will space allow of further exposition of the engineering accomplishments of Elihu Thomson's long life. Early in his career his genius for electromechanical construction, which his Philadelphia teaching had also developed, resulted in a business partnership with Mr. Edwin J. Houston, to form the Thomson-Houston Electric Company. This manufacturing business prospered and grew rapidly from 1882 to 1892, when it was united with Mr. Edison's organization to become the General Electric Company.

Elihu Thomson's achievements received general and laudatory recognition in the engineering world. Many were his citations and medals from scientific bodies in several countries. He was signally honored by the Massachusetts Institute of Technology in 1933 on the occasion of his eightieth birthday anniversary. He died at the full age of eighty-four, but a few miles from the New England city of Lynn, the vineyard of his fruitful labors for so many years. By the radiologist he should be remembered in gratitude, not only as one of the greatest of American engineers and inventors, but also in the light of his sympathetic championship of the cause of the "new science" in the day of its infancy.

WILLIAM THOMSON, BARON KELVIN OF LARGS (1824–1907)

The ancestors of William Thomson were originally Scottish Covenanters who, when driven from their native heath by religious persecution, became agriculturists in the North of Ireland. He was born in Belfast in 1824. His father, James Thomson, was a renowned mathematical scholar, his genius developed through hard-earned education at the University of Glasgow, who in 1814 had been appointed Professor of Mathematics at the Royal Belfast Academical Institution, and by 1832 was widely recognized as a distinguished teacher. The career of the father was destined to

exert a strong influence on those of his sons, James and William, who inherited his gifts in even greater measure. Having received an honorary degree from Glasgow University, James Thomson the elder was offered, in 1832, the chair of mathematics there, so to Glasgow he removed his large family. The two sons entered the University two years later and, with the endowment of their father's intellectuality, progressed rapidly under his guidance.

Before he was sixteen years old young William Thomson had completed his work at Glasgow in six "sessions," and in 1841, at seventeen, he was entered at St. Peter's College ("Peterhouse"), Cambridge, where he gained early distinction in the field of higher mathematics. His progress at Cambridge was consistently brilliant, as attested by the scholastic prizes and honors awarded him. He took his degree in 1845 and during this year also was elected a Fellow of St. Peter's College, even before his acquisition of the Master's degree in Arts. Immediate postgraduate study ensued at Regnault's famous laboratory in Paris, and later again at Peterhouse, where he was appointed College Lecturer in mathematics.

This post Thomson held but a few months. In 1845 the Chair of Natural Philosophy at Glasgow fell vacant, and his application for the succession thereto being accepted, he entered upon its duties in November of 1846 at the age of twenty-two! He sought at once to reorganize his Department. Thereafter for ten years his teaching and investigations dealt chiefly with certain branches of pure physics—thermodynamics, hydrodynamics and the dynamic problems of electricity, magnetism and of bodies in revolution. For example, in 1852, by means of a series of experiments with a Leyden jar, he found that under certain conditions of resistance and self-induction the motion of electricity is oscillatory, and worked out a formula by which the rapidity of the oscillations may be computed. This remarkable piece of mathematical analysis and Thomson's integral-deductions therefrom passed almost unnoticed at the time but which, through the later investigations of Hertz, Sir Oliver Lodge, Marconi and others, now constitutes the basis of wireless communication.

But William Thomson the physicist and mathematician possessed as well the genius of the engineer and the inventor. "In the middle fifties events were progressing which drew . . . him with irresistible force toward the practical applications of science which made him famous." The results of this diversion are familiar to all students of the history of scientific accomplishment. Suffice it to say that they are exemplified in over seventy practical devices on which he obtained patents. In 1855, his enunciation of the mathematical theory of electrical signalling through submarine cables led to his brilliantly successful supervision of the work of laying the "Atlantic submarine telegraph," in which his ultimate results were attained by the use of his mirror-galvanometer, following earlier discouraging attempts by others. To this procedure he later added the refinement of his siphon recorder, whereby were eliminated the frictional resistance of recording stylus upon paper and the ocular fatigue caused by constant direct observation of mirror-image fluctuations. For these epochal applications of his genius, resulting in the laying of the first successful Atlantic cable, Thomson received the Order of Knighthood from Queen Victoria in 1866.

Inventions of Sir William Thomson of more direct benefit to mariners were his sounding-machine, its steel-wire line making depth measurements scientifically accurate; his mariner's compass, which revolutionized navigation by its complete freedom from oscillation due to ship's magnetism, gun-fire or violent storms; his tide-predicting apparatus, and his introduction of the flash-system of lighthouse identification, now so familiar to sea faring people. The applications of his genius were equally varied outside the scope of maritime matters. He it was who solved mathematically the major problems attending

the production of a hydroelectric power system at Niagara Falls and the long-distance transmission of energy thus obtained. In 1890 he presided over a consulting commission appointed to devise such a system. Projects and estimates were invited and twenty-six different plans were submitted. No one was adopted in full, but some use was made of fourteen of them. In the light of present-day knowledge and practice, it is noteworthy that Sir William was utterly opposed to alternating current as the form in which this power was to be transmitted but his objection was overruled by the Commission.

On New Year's Day of 1892 a peerage of the Realm was conferred by Queen Victoria on Sir William Thomson, as the first Baron Kelvin of Largs (Ayrshire, Scotland), a name taken from the Kelvin River, a small stream which flows below and around Gilmorehill, the site of the new University Buildings at Glasgow.

The news of Röntgen's discovery did not find Lord Kelvin, as it did so many physicists, wrestling with the mensuration difficulties attending the passage of electricity through gases. At the moment he was deep in the problems of engineering mathematics, especially in connection with the new Pacific cable. But ultimately the discovery of both x-rays and radium was to affect his scientific theories and, indeed, his life's work. History records that he received the report as if it were an utter mistake or a hoax. He was "intensely sceptical" until Röntgen sent to him a copy of his *Preliminary Communication*, whereupon he wrote:

January 17, 1896.

Dear Prof. Röntgen—When I wrote to you thanking you for your kindness in sending me your paper and the photographs which accompanied it, I had only seen the photographs and had not had time to read the paper. I need not tell you that when I read the paper I was very much astonished and delighted. I can say no more now than to congratulate you warmly on the great discovery you have made, and to renew my thanks to you for your kindness in so early sending me your paper and the photographs.—Believe me, yours very truly,

Kelvin.

The simple words of this short note of acknowledgement concealed the emotions of what a biographer of Kelvin calls the most tragic moment of his life. He was

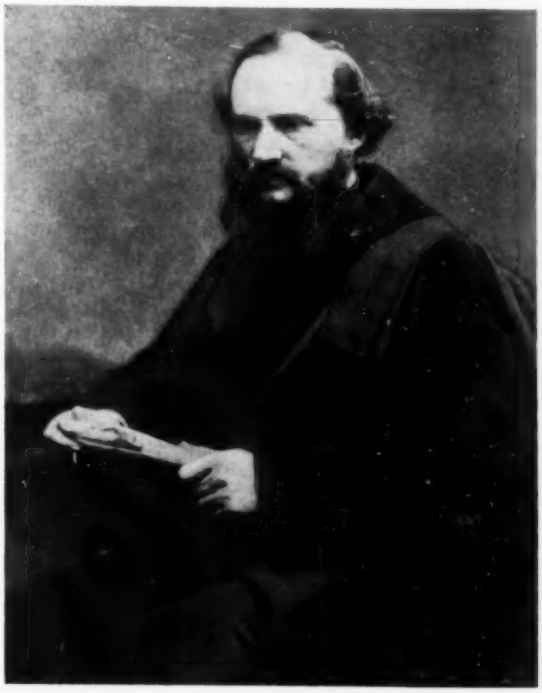

Fig. 3. Lord Kelvin (William Thomson). (Photograph by Fergus.) (Courtesy Macmillan and Co., Ltd., London.)

then seventy-two years old. Early in his career he had set for himself a high ideal. To attain this ideal his purpose was to work out a Great Comprehensive Theory of Matter, to determine the nature of the substance of the Universe, "to bring together all that is known of electricity and magnetism and the structure of the atom and the nature of the ether, and to weld all these together into one grand and final synthesis." He believed that this could be done; that almost within his grasp was the moment of full accomplishment when he should find *how* Nature performed the marvels which he knew—by discovery—

she did perform. But the discovery of Röntgen and, a bit later, that of the Curies, overturned his previous theories and reopened for him the problem of the qualities of matter. "I now abandon everything I have ever thought of or written in respect to the constitution of the ether," was the reaction of one of the greatest natural philosophers the world has ever known.

Subsequently, from 1896 to 1898, Lord Kelvin undertook a series of experiments dealing with the electrical phenomena produced in gases by roentgen rays, with the conductive effect produced in air by roentgen rays and by ultraviolet light, and with the physical effect on solid dielectrics produced by roentgen rays, but radiology's real debt to him is but a part of the indebtedness of applied science as a whole, which dates back to his renowned *Baltimore Lectures* of 1884, delivered at the Johns Hopkins University to a postgraduate group of about fifty men, twenty-one of them being highly trained physicists whom he affectionately called his "twenty-one coefficients."

The Baltimore Lectures had a profound effect on those who heard them and eventually on the teaching of engineering and applied physics in the United States. Kelvin's methods of instruction, especially the use of models, and the clear presentation of his mathematical formulae, fascinated his audience. Under this new conception of teaching the fresh seed of his remarkable mentality took root in keen brains. Scientific thought, by being turned into unusual channels, was refreshed. Charged with the stimulus of his enthusiasm, his simplicity and his intellectual honesty, his "coefficients" and the other scientists who sat under him, went forth at the close of the Lectures to spread abroad his teachings. We have but to contemplate the expansion of applied science in America since that day, to appreciate the educational influence of his extraordinary personality.

William Thomson died in December of 1907. He was buried in Westminster Abbey and there, beneath its nave, he lies, in the one place where he, of all illustrious Britons, should lie—next to the grave of Isaac Newton.

"Science never had a more enthusiastic, stimulating or indefatigable leader."

SILVANUS P. THOMPSON (1851–1918)

Silvanus Phillips Thompson, engineer, physicist, artist and author, was of the ancient family of Thompson of Strickland and Morland, in the English county of Westmorland. In the middle of the Eighteenth Century three of his forbears became members of the Society of Friends and although they suffered, in consequence, from the effects of religious persecution, the Quaker faith persisted through the succeeding generations of the family. Nevertheless, the father of Thompson, Silvanus Thompson the elder, seeking an education during the days of his youth, was denied admission to Cambridge or Oxford because of this faith and compelled to repair to University College in London for the training of a teacher. This obtained, he married and removed to the city of York, where his son was born in 1851. The younger Silvanus Thompson duly received his higher education at the University of London along scientific lines, for which he was prepared at Bootham (Friends') School in York, where his father taught, and later at the Quaker training college at Pontefract, Yorkshire. His University days over, young Thompson began his teaching career immediately, first as Science Teacher at Bootham School, then as Lecturer in Physics at the new University College at Bristol and later at Finsbury Technical College in London, of which he became the Principal in 1885. In 1900 he was elected to the Senate of the University of London, in the affairs of which, as a prominent graduate, he was actively interested. During all these years he gave popular lectures on many subjects, aside from his college curricular work. He was very successful in presenting abstruse matters before assemblies of young people and had written in 1881 his "Elementary Lessons in Elec-

tricity and Magnetism" in the form of a school class book. This publication proved its popularity by appearing in sixteen printings from 1882 to 1914.

It is reported by Thompson's biographers that at the moment of the first of Röntgen's *Communications* he "had been working on the very lines on which Röntgen had made his discovery." Sir William Crookes, by his striking experiments of four years before with vacuum tubes had given great impetus to the research of many physicists on kindred problems connected with the relationship of electricity and light. Thompson, similarly stimulated, immediately grasped the physical minutiae described in detail by Röntgen. He eagerly repeated these results in his own laboratory. Shortly afterward, while at work on experiments involving certain salts of uranium, he observed phenomena precisely similar to those described by Henri Becquerel and at almost the same moment. Becquerel reported his results in February; Thompson's report, although ready, was not read until June. Therefore these new manifestations were called the "Becquerel Rays."

Late in 1896 Thompson, impressed and perhaps a little disgusted at the influx of scores of reports of "discoveries" in connection with the new x-rays, published a report of his own on "X-ray Myths" in which he showed the ridiculous nature of the theories upon which these reports were based. But for a short time during that astounding year of 1896 he himself expressed the hope that some form of artificial illumination might be evolved on the basis of the phenomenon of "luminescence." This thought was kindred to Edison's conception of illumination obtained by the utilization of fluorescence, but which was found to be not only impractical but dangerous. Thompson believed that the "luminescent lamp of the future . . . will be one giving a pure and a cold light that will neither poison the air with the fumes of combustion or overheat it with wasted calorific vibrations."

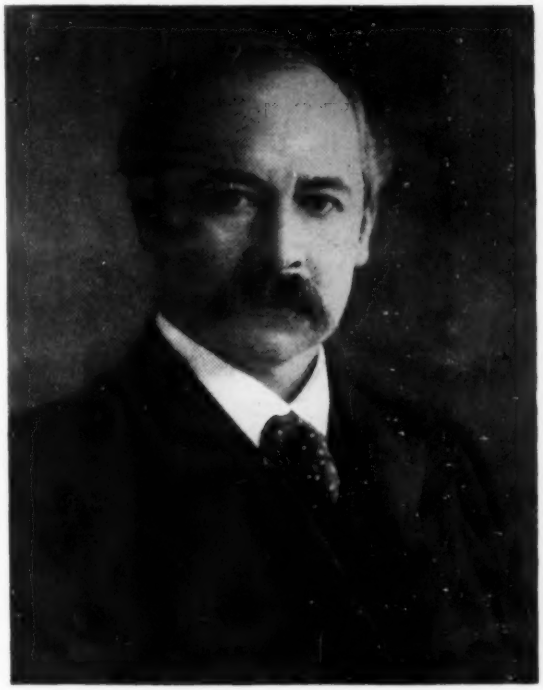

Fig. 4. Silvanus P. Thompson. (Courtesy E. P. Dutton and Co., New York.)

In the spring of 1897, a group of London medical men envisaged an increasing diffusion of knowledge relating to the "new science" through the formation of a "Röntgen Society" in London—the first organization of its kind. They invited Thompson to become its President. This office he accepted. Although this was the first society of scientists dedicated to the advancement of what would now be called radiology, it did not develop preponderantly along medical lines, as intended by its founders. Yet it maintained for years a catholicity of interests by the alternate presidential election of a medical man and a physicist. After the first World War, the Röntgen Society was fused with the British Institute of Radiology. In 1897, Thompson wrote his very successful *Light Visible and Invisible*, which was translated into the German, but it may be safely said that the chief examples of his indubitable literary ability were his *Life of Faraday* (1898) and his *Life of Lord Kelvin* (1910). His published *monographs* extended from 1879 to 1918—

one being posthumous—were seventeen in number and almost entirely scientific in character.

A year after Silvanus Thompson's death in 1918, a Memorial was endowed by the Röntgen Society to its first President in the form of an annual Lectureship. The first lecture under this endowment was delivered by the late eminent physicist, Sir Ernest Rutherford. His words describe succinctly but accurately the varied activities of this remarkable man:

> . . . he was a man not only distinguished as a teacher, investigator and writer on technical science, but was, in addition, greatly interested in the advance of pure science, especially in the domain of optics. . . . It was his interest in all types of radiation that led him to make experiments on x-rays immediately after their discovery. . . . Subsequently he was able to show that the efficiency of x-ray tubes was increased by the use of heavy elements like platinum and uranium as anticathode, and made other researches on the effect of a magnetic field on the discharge in a vacuum tube. . . .
>
> In reading again the admirable presidential address of Professor S. P. Thompson to this [Röntgen] Society in 1897, . . . one cannot but recall the extraordinary interest aroused, in the lay and the scientific mind alike, by the discovery of the Roentgen Rays. Naturally in his address, prominence was given to the medical application of those rays for the advancement of which the Röntgen Society was primarily founded, and for which it has done such admirable work. . . .

Even if modern medical Radiology were to acknowledge her debt to the Thomsons and the Thompsons for nothing else, she can ill afford to ignore her obligation to Silvanus Thompson for his devotion to the Röntgen Society until the day of his death. This prototype of the great radiological organizations of today might have continued as an association of physicists had it not been for the foresight and mental breadth of one who was not himself a physician. His constructive allegiance was ample indication of his sympathetic attitude toward that humanitarian application of the "new science" to which so many medically trained men have since dedicated their professional lives.

Doctor Thompson died suddenly in June of 1918. His versatile career held that proportion of triumphs and disappointments which is usually the lot of the experimental scientist. From his triumphs he experienced a quiet and dignified satisfaction not unmixed with generous concern lest he may have received more than his share of credit or honor. His occasional disappointments were either promptly belittled under the allaying influence of his resilient courage or totally concealed beneath the cloak of his imperishable optimism.

EDWARD P. THOMPSON (1856–?)

The chronicler of radiation history first comes into contact with the name of Edward P. Thompson when reviewing the course of the amazing events which condensed the scientific atmosphere of the year 1896. A renewal of that satisfying contact, during succeeding decades, has been difficult if not impossible, but he who browses from old radiological bookshelves will be apt to find a permanent and intimate record of painstaking accomplishment as a product of those crowded days.

Edward P. Thompson was graduated from the well-known Stevens Institute as a mechanical engineer, but while there he made electricity a special private study in connection with his curricular work in philosophy and chemistry. From 1878 to 1882, he taught privately daily classes in physics by the aid of experimental demonstrations, as well as advanced geometry and higher algebra. In periods of respite from this teaching he "discovered and developed the expansion of polynomials [which was] published in the *Mathematical Visitor*." During the years 1883 and 1884, Thompson's attention was turned more directly into engineering fields, and especially to the work of assisting in the introduction abroad of the Brush inventions, one of which was the electric arc-lamp, and to the commercial development of the

Swan (British) incandescent lamp in the United States. In his laboratory activities in connection with this work he tested many and various types of electrical apparatus with reference to existing defects and possible improvements, which led to many inventions of his own.

In 1885, Thompson engaged in the business of applying for patents on electrical inventions on behalf of clients of the *Electrical World* (N.Y.) Patent Agency. Then and subsequently he did much writing for this publication and as its Consulting Electrician he edited its Department devoted to the matter of electrical patents.

Edward Thompson was elected in 1889 to regular membership in the American Institute of Electrical Engineers, from which he resigned in 1916. The archives of that Society offer practically no information concerning his professional activity since then and, indeed, very little about him during the years immediately following Röntgen's discovery. We have it from Thompson's own pen, however, that he entertained an early and lively interest in the subject of fluorescence. He was prompt to question the term "fluoroscope" on the perhaps over-nice ground that it is the shadow resulting from fluorescence, rather than the phenomenon of fluorescence itself, that is under investigation. No doubt spurred by his belief in the necessity of this distinction, Thompson devised an enclosed barium platino-cyanid screen, for single-hand use, which he called a "Kinetoskotoscope," but possibly the weight of its name may have precluded its use as a single-hand instrument, for the term can be no longer found in the nomenclature of later years.

Any mention of Thompson's pen will recall to the minds of older roentgenologists the one monument that perpetuates his name in roentgenological history—his remarkable book, which appeared in 1896 under the title "Roentgen Rays and Phenomena of the Anode and Cathode," with a concluding chapter by Professor Anthony, formerly of Cornell University. Its textual arrangement may appear strange to readers of the usual American scientific monograph. Its fourteen chapters, the one in conclusion excepted, are subdivided into sections, each section dealing with some definite contribution, based on experiment, to the antecedent or direct development of what we now know as roentgenology. For purposes of correlative cross-reference, each section is numbered and otherwise treated as an entity, however brief it may be. Chronological order largely controls the arrangement of the sections; from number one, reciting the details of Faraday's induction experiment of 1831, to number two hundred and ten, which mentions five contributions to the medical and surgical application of roentgen rays, each of which must have been, in the early months of 1896, a triumph of science. One hundred and ninety pages were never more usefully engorged with historical information. They reveal, for example, the source of many of our modern procedures in a description of oil-immersion of the discharge-tube, on the basis of experiments by Tesla, Edison and Trowbridge. They revive graphically, from the misty past, theories of tube-construction that today must be well-nigh forgotten, such as that astounding example wherein it was believed that added strength of emanation was to be obtained through a combination of electrodes both within *and without* the wall of the discharge-chamber.

Although Edward Thompson apparently soon abandoned the field of radiation investigation, he has left his mark behind him. For his painstaking labors on behalf of inquiring enthusiasts who should follow him, radiologists of his day feel that they owe much; those who are younger, but who appreciate the historical reason for things they do in their daily practice, cannot properly banish the same sentiment.

Whether or not history "repeats itself," there is much of it that bears repetition or at least is worthy of periodic re-examination and study beyond mere casual reference for purposes of fact-finding. History

indeed provides facts both necessary and welcome, but these are held in proper relation to each other by a connective tissue of supporting detail without which, especially in the history of an expanding science, they would be deprived of much of their meaning. The value of this supporting network can be thoroughly realized only when we turn back the pages, for there is much to be mentally re-absorbed and really very little to be forgotten, of the perpetual human effort by which it has been woven.

A very small group of scientific men was chosen, by the accident of name, as the subject of this brief turning back of the pages, not merely to present the historical facts their careers create, but to reveal their individual calibre in support of these facts—the high purpose, scientific enthusiasm, sincerity and intellectual honesty common to such men. Since their record is once again momentarily disclosed—a record of splendid lives pursued in the humility engendered of close contact with the wonders of Nature's physical laws, it is to be hoped that it may meet the passing view of the radiologist of a new generation as he bends to the tasks of his chosen profession.

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PRINCIPLES OF RELATIONSHIP BETWEEN HOSPITALS AND RADIOLOGISTS*

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AT FIRST thought it seems strange that there should be any occasion for discussing principles of relationship between hospitals and radiologists, for radiologists are physicians, and their relationship to the hospital should be precisely the same as that of other physicians on the hospital staff. However, special circumstances are involved in the relationship between the hospital and the radiologist, and in certain instances one or the other party is open to the accusation of unfair dealing. Explanation, though not excuse, for these unsatisfactory conditions can be found in the historical background of medical radiology and in many other contributing factors.

At the beginning, the importance of the rôle that the roentgen rays were destined to play in the diagnosis and treatment of disease was not realized. In most hospitals, the first roentgen apparatus was bought and installed by a staff physician who was interested in the new agent and dimly foresaw some of its capabilities. Usually, an orderly was assigned to assist in the work and he soon became proficient in the simple techniques then required. Diagnoses, which were then limited chiefly to fractures, dislocations and foreign bodies, were more or less self-evident, and the embryonic roentgenologist was regarded mainly as a supervising technician. Fees, if charged at all, were small and few difficulties arose over their apportionment. Then, through the efforts of pioneer radiologists, the radiologic field began to widen in scope and importance. Roentgen rays were employed successfully to disclose disease of the lungs, the alimentary canal and the urinary tract, and radiotherapy grew in efficiency and extent. Hospitals not previously equipped bought apparatus or solicited installation of equipment by a radiologist. Respect for the radiologist's opinions as to diagnosis and treatment increased, but the shadow of the past hung over him, and it was still felt that he was a photographer, electrician, technician and physician combined, and that the professional element was incidental rather than essential. Clinicians spoke of having "an x-ray picture" made. Even today that phrase is sometimes heard. As progress continued, receipts of the radiologic department of the hospital grew to a substantial aggregate, but until 1929 no serious difficulty arose over their distribution. Then came the depression. Actual incomes assumed greater importance than quotations on stocks. Equitable allocation of receipts from the radiologic department became a vexing problem, and in many instances the claims of the hospital and those of the radiologist conflicted strongly.

In the view of many hospital administrators, the radiologic equipment, however acquired, was an integral part of the institution, an indispensable facility that was properly subject to control by the hospital. The radiologic department was rated as a laboratory rather than as the office of a staff consultant, for most of the visible work was, or could be, performed by lay assistants. Indeed, during most of this period radiology was not recognized as a medical specialty; technicians and physicians alike claimed to be radiologists, and they varied widely in competence and in their estimates of the value of their services. Consequently, some of the more thrifty hospitals were inclined to look for bargains in this respect. Often, the function of the radiologist was nominal rather

* Read before the Twenty-second Annual Hospital Standardization Conference, Philadelphia, Pa., Oct. 16–19, 1939.

than actual, for many diagnoses were self-evident, and his interpretation was not needed. Patients were sent to him in numbers and as a routine, not singly and selectively referred as was the case at his office. Hence, the hospital felt that it had first claim to the receipts of the department, that it could rightfully give the radiologist the least that he would accept, and that its title to any remaining surplus was incontestable. Back of this feeling was the fact that most hospitals were, and still are, benevolent institutions, built and endowed by philanthropic persons or organizations, obligated to give much service gratuitously as a matter of charity, conducted without thought of showing any return on capital investment, and often partly dependent on donations or taxes for maintenance. Thus, it was felt that criticism of the hospital's fiscal policies was ungenerous if not hostile.

On the other hand, the radiologist, conscious of his rights as a physician and of the value of his professional services, regarded appropriation by the hospital of a large part of his earned income as unethical and unfair; unethical because it made the hospital a practitioner of medicine; grossly unfair because the surgeon, the internist and other specialists on the staff, were not subject to any such levy. Even conceding that the levy would be benevolently applied, the radiologist saw no reason for singling him out to make the sacrifice.

Inequities and friction were bound to come out of this welter of incongruous circumstances, conflicting attitudes and ancient history. Some hospitals made the radiologic department a major source of income by paying the radiologist an inadequate salary, or by taking an undue percentage of receipts when that was the basis of allotment. In some instances they attempted to justify their action by using plausible but unfair methods of bookkeeping. For example, I know of an instance in which the annual gross income from the radiologic department was approximately $75,000, yet the hospital firmly contended that it could not afford to pay a salary of more than $5,000 to the radiologist. This contention was superficially supported by a clever method of bookkeeping, by means of which part of the interest on the hospital's bonded debt and even a portion of the general expenses were charged to the radiologic department. In another instance, of which I have intimate personal knowledge, the radiologist owned the equipment, furnished supplies and help and allowed the hospital to retain a percentage of the fees as rent. The radiologist's charges were included in the hospital's bill, but were entered as the last item of the bill. For example, if the whole charge was $200, including a ten-dollar radiologic fee, and the patient paid only $190 or less, the radiologist was told merely that his fee had not been paid. One of the sorest points in the controversy has been the inclusion of certain medical services, notably those of the radiologist and pathologist, in group hospitalization benefits. By such inclusion the hospital engages in the practice of medicine and the rights of the radiologist are ignored.

On the other side of the picture, some hospitals have complained of exploitation by the radiologist, notably by the radiologist's charging fees that were not warranted by the service rendered, or by giving too little personal attention to the department, or by failing to make himself available for consultation whenever needed.

I recount this sequence of events, not to dig up old bones of contention and to renew bickering, but to show that strained relations between hospital and radiologist were inevitable results of antecedents for which neither party was wholly to blame, and that ensuing injustices were not confined to one party alone. Certainly, there is no occasion for reviving controversies, for their causes have largely been removed. At long last radiology has been accepted as a special branch of medicine. The right of the radiologist to consider himself a specialist and his competence as such are determined by The American Board of Radiology which, with the approval of the American

Medical Association through the Council on Medical Education and Hospitals, prescribes stringent requirements for candidates seeking the Board's certificate. Radiologists and hospitals have arrived at a broader understanding of each other's rights, duties and problems. Both are beginning to recognize their community of interest and need for mutual cooperation. Far-reaching and fair adjustments have been made, and the relations between most hospitals and their radiologists are harmonious. In exceptional instances, however, the method of allocating income from the radiologic department is not satisfactory to one or both of the parties most concerned, and a consideration of fair bases of adjustment is in order. As to such bases I have opinions that I am quite willing to express, and, although I speak only for myself, I am assured by the Inter-Society Committee for Radiology that the plans to be suggested will be approved by most radiologists.

All bases of allotting radiologic receipts that I shall suggest or endorse rest on the assumption that each party will freely acknowledge certain fundamental rights of the other, including the following: The radiologist is entitled to a share in fees proportionate to the amount of work done and in reasonable ratio to the income of radiologists doing a comparable volume of work in private practice and to that received by other members of the staff from their work in the hospital. It is his right also to nominate his assistants, to fix fees and to have unhampered direction of the department. In short, so far as circumstances reasonably allow, the radiologist should have the same privilege as other members of the staff in performing his duties and receiving recompense therefor.

Certain rights on the part of the hospital also must be recognized. With few exceptions, the hospital is entitled to compensation for space used by the department and for the use of equipment, if it is owned by the hospital. An exception to this rule might be the hospital that is closely allied with a medical group and receives patients only from that group, the latter equipping and paying all expenses of the department. In such case the intimate and complementary relationship between the hospital and the group precludes any claim by the hospital for remuneration. In determining the recompense due to a hospital, it is entirely proper to consider not only capital investment but also the amount of work done and the receipts of the department. Further, the recompense may well be generous if the hospital is not operated for profit. Every hospital is entitled to efficient and timely service by the radiologist. When he serves two or more hospitals, each of them has a right to claim an adequate measure of his personal attention. I want to point out, however, that complaints on this score have sometimes arisen from the fact that two or more hopitals have insisted on being served by the same radiologist because they considered him to be especially well qualified or because he was the sole radiologist available. In such instances, when work is demanded simultaneously by the hospitals, it is impossible for the radiologist to perform all the work at the moment in person, and he is obliged to postpone service at one or the other or consign it to assistants. If assistants are to be entrusted with a large share of responsibility, the fact should be mutually understood at the outset and the hospital is warranted in requiring that the assistants be competent. Indeed, competent, faithful, prompt and cooperative service by the radiologist can scarcely be stressed too strongly, for in the many instances in which the relations between the hospital and the radiologist have always been harmonious, that kind of service has invariably been given.

Of the various fiscal plans that have been tried or proposed, the fairest, it seems to me, is that by which the radiologist rents or leases space from the hospital for the department, which he equips and conducts precisely as he would conduct his private office. The amount paid as rental may be either a fixed sum or a percentage of the gross receipts. On the latter basis from 15

to 20 per cent will usually be equitable. All patients' fees should be billed and collected directly by the radiologist. By means of this plan he preserves his professional independence and has undivided responsibility for the efficiency of the department. If the hospital owns the equipment, this also can be included in the lease, and when relations have proved to be mutually agreeable an arrangement may be made by which the radiologist purchases the apparatus by amortizing payments over a period of ten years, which is a liberal allowance for complete depreciation of equipment. Meanwhile, he furnishes all help, supplies, maintenance and replacements. I have known of instances in which this plan worked to the satisfaction of all concerned.

Next, in preference, as I would rate it, is division of the gross receipts between the hospital and the radiologist on a percentage basis. This plan is feasible when the hospital owns the equipment of the department, pays all expenses, including those incurred for technicians and current supplies, and employs the radiologist or radiologists solely to do and direct the work of the department. The percentage appropriate for the radiologist will vary among hospitals according to the character and volume of the work, but usually will range between 40 and 60 per cent. As a rule, the radiologist will expect a higher percentage from a small hospital than from a large one, but in any case the hospital is entitled to a fair return on its investment and space. This plan becomes more nearly ideal when all fees are charged, billed and collected directly by the radiologist. When either the percentage or rental basis is employed, the radiologist should donate his services to charity patients freely and in keeping with the generosity of the hospital and that of other members of the staff.

Least desirable of all plans, in my opinion, is employment of the radiologist by the hospital at a fixed salary, for the arrangement can easily be abused and often gives rise to discord. Nevertheless, it is a convenient and practicable plan if the hospital has a large and constant volume of work or if other members of the staff are remunerated by salary. The plan can be made to function equitably if the radiologist's salary is proportionate to the amount of work he does and if the net remaining surplus is not greater than the amount of money that the hospital might reasonably expect to receive as a return on investment. Neither this plan nor any other should be made a cover for including radiologic services to groups carrying hospitalization insurance. However, a provision for cash payments in specified amounts to the beneficiary, who in turn will pay the radiologist for his services, will have the approval of all radiologists.

Under any fiscal arrangement the account books of the department, whether they are kept by the radiologist or the hospital, should, in my opinion, be open to inspection by the other party. This frankness will promote harmony, forestall unwarranted suspicion and facilitate any necessary adjustments. If under any plan the receipts of the radiologist or the hospital from the department are excessive as compared with those derived from similar amounts of work performed by other radiologists and hospitals, a reduction of radiologic fees to patients in the lower brackets of income should be considered. For this there is more than one good reason.

Aims and interests of physicians, hospitals and public are identical. The welfare of all three is threatened by efforts to socialize medicine. If state medicine is established, the hospitals will become victims of political racketeers and the humanitarian aims of founders of hospitals will be utterly defeated. Under the direction of bureaucrats, physicians will become apathetic hirelings, and medical service to the public will sink to the nadir of efficiency. Most vociferous among those who urge setting up totalitarian medicine are the demagogues, and their appeal, which is designed solely to get votes, is directed primarily to persons in the lower segment of the economic scale. At the lowest extreme are the poor, who

have long received excellent medical care gratis in public or private hospitals and free clinics, and physicians have treated them at their homes without expecting or receiving pay. Such persons would be foolish indeed to listen to the politicians. At the top of the scale are the rich whose number and assets are rapidly diminishing, but who are not yet personally concerned about medical costs. In between are the great masses, who are Americans, individualists, anxious to maintain their economic independence, and who do not wish to be objects of charity or governmental solicitude. To many in this group standard costs of medical care are burdensome, especially in times like these. Abundant precedents for reducing fees of such patients have been set by the family physician, by specialists and by medical groups. Reduction should not be carried to the point of putting the hospital radiologist in unfair competition with the radiologist in private practice, but that conflict can be avoided. Such reduction would not necessarily cut the radiologist's income. On the contrary, I believe that his income will be increased as a result of an increased demand for his services. If the roentgen rays and radium were used as often as they should be, no radiologist would have reason to complain of his lot.

At all events, I feel strongly that hospitals and radiologists should cooperate more actively to make hospital and radiologic services more readily available to all who need them and at rates commensurate with the patient's ability to pay. With state medicine looming large on the horizon, hospitals and radiologists should quickly compose their petty differences and together with the general medical profession and the public, make common cause against a common enemy.

MEASUREMENT IN ROENTGENS OF THE GAMMA RADIATION FROM RADIUM BY THE FREE AIR IONIZATION CHAMBER

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I. INTRODUCTION

THE free air* ionization chamber is the accepted standard for calibrating roentgen-ray dosage measuring instruments. With the advent of million volt roentgen rays, the need for proved standards for this range has risen. In a recent publication[21] the application of the free air ionization chamber, with certain pertinent modifications in technique and necessary precautions, was described, in which was proved the adequacy of the free air chamber for measuring roentgen rays up to 400 kv. excitation potentials. This work still leaves its application to the higher frequency radiation untested.

Equipment is under construction to extend this investigation to 1,400 kv. In the meantime, the applicability of the methods has been investigated by studying ionization produced by gamma rays of radium. These rays comprise radiations ranging from 600 kv. to 2,000 kv., roughly comparable to 1,500 kv. roentgen rays. The ionization produced at unit distance from 1 mg. of radium is an important physical quantity, uncertainties in which arise largely from experimental difficulties inherent in realizing the definition of the roentgen for very high frequency radiations. The measurement of roentgen rays and gamma rays by means of the same instrument and procedure lends greater confidence to the expression of roentgen- and gamma-ray dosages in a common unit—the roentgen.

The ionization produced by a narrow collimated beam of gamma rays in an air ionization chamber at pressures up to 10 atmospheres has been measured. The investigation involved:

(1) A study of the dimensions and pressures required to eliminate wall effects. This involved a study of the general ionization chamber design with particular respect to the plate spacings and diaphragm-collector distances at various air pressures so as to insure a state of full electronic equilibrium. It also included an investigation of the diaphragming and collimating system necessary to the unambiguous measurement.

(2) A determination of the correction for columnar recombination and lack of saturation. Current-voltage saturation conditions were studied, and Jaffe's theory of columnar ionization was applied to determine the saturation current.

(3) A determination of the fraction of the total gamma radiation reaching the ionization chamber. This involved a review of the fundamental calibration methods for radium preparations, with relation to the measurements of the emission constant of radium in accordance with the definition of the roentgen. Included in this were corrections for the absorption of the gamma rays in air, platinum and the radium salt itself.

(4) Finally, the various experimental results were applied to an evaluation of the emission constants of radium in roentgens. After an analysis of the various errors involved, the results were compared with similar determinations by other methods.

* A "free air" ionization chamber is one wherein the volume from which the ions are effectively measured is surrounded by an envelope of air having a thickness in all directions at least as great as the maximum range of the secondary electrons entering or leaving the volume in those directions. For low voltages, the ionization chamber is usually used with air at atmospheric pressure and is frequently termed an "open air" ionization chamber. In this paper the use of the term "free air" is extended to those chambers operating with air at elevated pressures.

The use of a relatively large quantity of radium facilitated measurements at low current sensitivities and for satisfactory distances, so that quantities involving these measurements could be evaluated with high accuracy and permit the more ready localization of any other errors.

This work was made possible through the cooperation of the National Institute of Health, which loaned us, for the purpose, a specially made platinum cylinder containing about 0.5 gram of radium.

II. HIGH AIR PRESSURE IONIZATION CHAMBER

The ionization chamber employed in this investigation has been described in detail[21] in connection with supervoltage roentgen-ray investigations, no changes having been made for this study. Briefly, it consists of a guarded field parallel plate chamber (75 cm. long with a maximum plate separation of about 40 cm.) placed in a steel pressure tank 8 ft. long and $2\frac{1}{2}$ ft. in diameter, suitable for operating normally up to 10 atmospheres and, if needed, at double that pressure. Plate separation and position along the axis of the cylinder are adjustable from without through suitable air tight joints. An aluminum "window" 1.0 mm. thick and 6 cm. in diameter permits the effectively unobstructed entry of the radiation beam.

Air was supplied from a small compressor with intake passing through a large calcium chloride dryer, and outlet through a cylinder packed with rag waste to absorb any oil vapor or other foreign matter from the pump. Several canisters of $CaCl_2$ dryer were also placed in the tank to remove any final traces of moisture, so that all measurements could be made under dry air conditions.

Up to about 4 atmospheres, the pressure was measured with a multiple tube mercury manometer[14] to an accuracy of ± 0.1 per cent. At higher pressures a Bourdon gauge, calibrated with a piston gauge to an accuracy of ± 0.3 per cent at the particular gauge points of the study was used.

Saturation voltage was supplied from either of two sources, depending upon the magnitude of field required and the electrometer system employed. With the more sensitive vacuum tube electrometer, very small fluctuations in the saturating voltage induced large deflections of the galvanometer. By test, it was found that fluctuations in the plate voltage exceeding ± 0.01 volt were intolerable; consequently where plate voltages of 10,000 are used a steadiness of 1 part in 10^6 is required and 1 part in 10^7 desirable.

For potentials up to 8,000 volts, heavy duty "B" batteries were employed. Although an individual cell is probably not steady to the required degree, the fluctuations of the 5,000 cells were statistically balanced and the resultant voltage was steady to 1 part in 10^8.

Above 8,000 volts, a valve rectifier-filter was required. Stabilization of these voltages within our required limits proved to be impracticable by any of the usual methods; our requirement that the output voltage be variable was one of the main difficulties. An attempt to use the manual compensation method described by Pallister and Smith[16] showed it to be inadequate for our needs. Indirect compensation was finally accomplished through a modification of the Swann methods, whereby a definite fraction of the fluctuating plate voltage is applied to the electrometer grid circuit in such a way as to balance out the plate voltage variations.* By this means, plate voltages up to 25 kv. were available.

Careful tests were made for any possible corona or other leakage at these high plate voltages. At atmospheric pressure, corona hissing began at about 4,000 volts and breakdown occurred at about 15 kv. Up to the latter point, there was no visible corona nor did any corona occur in regions such that it could be detected with our highest electrometer sensitivities. At 10 atmospheres, tests up to 30 kv. showed no breakdown or visible corona, nor was any leakage effect detected by the electrometer. It

* This will be described elsewhere.

is interesting to note that after any prolonged pumping of air into the cylinder, the electrometer showed erratic deflections attributable to stray ions (or probably ion clusters) caused by the air friction. At times it required twenty-four hours' rest after pumping for this effect to completely disappear. Broxon and Meredith[1] found similar disturbances in their very much smaller system and sometimes allowed several days for "aging" of the air.

Current measurements were made by essentially the same means used in our earlier roentgen-ray measurements.[21] For comparative current measurements, the ion current was balanced against a known current through a very high (S. S. White) resistor. For absolute measurements, the same electrometer system was used as a null detector in a capacitance compensator system.[18]

In both comparative and absolute measurements, the current was read in terms of a known voltage applied across the resistor or capacitor. This voltage was adjusted and read directly on a Leeds and Northrup type K potentiometer with an accuracy far beyond our requirements.

The need for shielding from radiation around the electrometer and conductors was carefully investigated. The radiation field was considerably restricted by the strict shielding and collimation at the radium as described below.

The electrometer tube was placed in a lead cylinder (wall, $\frac{1}{4}$ inch) which in turn was supported just outside the end of the pressure tank opposite to, and about 10 feet from the radium. Under these conditions, and with a relatively large testing potential difference applied between grid circuit and the shield, no ionization current was detectable at the highest sensitivities used. In normal operation there is practically zero potential difference between grid leads and case.

In the capacity compensating system the capacitor had an ionizable volume of about 20 cc. and was subject to a potential difference of several volts between plates. This, shielded by about 2 cm. of lead shot, also showed no evidence of stray ionization between plates. A third electrometer tube housing having no lead shielding but capable of being evacuated was also tested and the system found insensitive to radiation either at 760 mm. or at 10^{-2} mm. pressure.

Statistical variations in ionization produced by the radium caused random fluctuations of the electrometer zero amounting to about 2 per cent of the measured current when using the galvanometer employed in earlier studies. These fluctuations were reduced to a level of about 0.5 per cent of the working deflection by increasing the galvanometer period, although the measurements were thereby made somewhat more laborious.

III. DIAPHRAGMS

For most comparative measurements the construction, thickness, and alinement of the diaphragms are not important so long as the open and closed positions are reproducible. For absolute measurements, however, the thickness must be sufficient to reduce the radiation leakage through the walls of the diaphragm to less than 0.1 per cent of that through the orifice. To avoid the thick diaphragms necessary with radium, most workers have collimated the radiations by imbedding the radium in a lead block at the bottom of a deep well with walls of requisite taper. This collimating arrangement, requiring the presence of some sort of shutter system, makes it somewhat difficult to properly evaluate the scattered and background radiation. In an endeavor to avoid this difficulty, as well as to retain a system suitable for measuring roentgen rays of very high voltage, a diaphragm arrangement was constructed on the same general principle as for their measurement of such roentgen rays.

A practice in the past has been to use diaphragms which were too thin; and to make corrections by subtracting from the reading made with the diaphragm open, that made with the diaphragm closed; and

thereby supposedly eliminating the background radiation. For radium, this procedure is not valid for the following reason: Take a gamma-ray beam partially limited by a lead block, A (Fig. 1), and further by the limiting diaphragm, B, of thickness t. With the aperture open, the box filled with 0.02 inch lead shot) mounted on rollers; A is an iron can (35 cm. diameter, 50 cm. high) filled with lead shot in which is mounted, opposite appropriate windows, a thin copper tube cc', 10 mm. inside diameter for carrying the radium, R; $\mathcal{J}$ is a hollow cylinder having its $2\frac{1}{2}$ inch

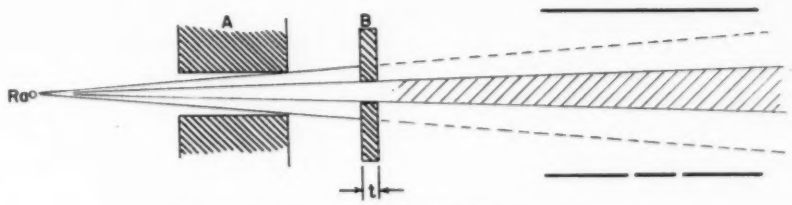

FIG. 1. Diagram of thin diaphragm system.

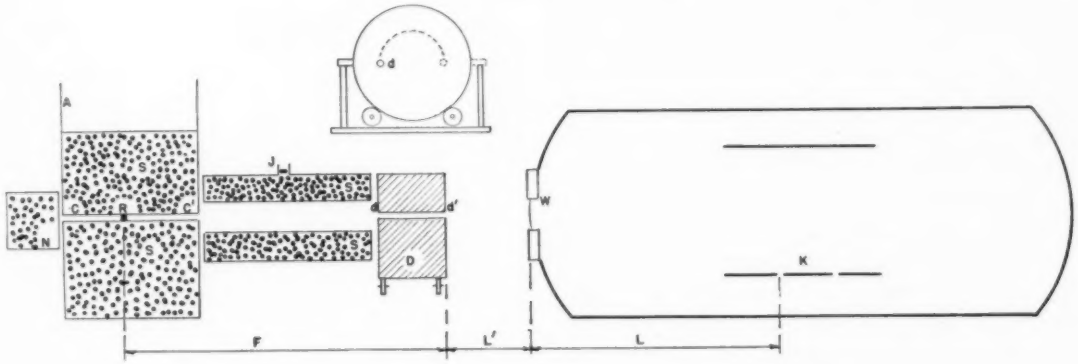

FIG. 2. Diagram of thick diaphragm and collimating system.

total radiation measured is the unobstructed part passing through the aperture plus that which passes through the surrounding wall. With the aperture closed by a plug, the radiation measured is again that which passes through the wall plus that which passes through the plug. The difference in the two measurements gives that passing through the aperture plus that which passes through the plug, and the result consequently in error by the latter amount. This error is reduced by increasing the thickness, t, of the diaphragm. Since, then, the resultant quantity is a function of the diaphragm thickness, t, the thickness should be made so large that no appreciable amount of radiation passes through it.

The arrangement of the system finally adopted is shown diagrammatically in Figure 2. N is a 5 inch lead screening cube (or wall filled with 0.02 inch shot; D is a brass tube (diameter 6 in., length 6 in.) filled with solid lead through which is drilled an eccentrically placed orifice dd', so that by rotation of D in its supporting saddle, the orifice can be either entirely open to, or completely shielded from the radiation from R; and finally, the pressure tank with aluminum window, W, and ionization chamber, K.

The limiting aperture dd' was formed by first drilling a commensurate hole and then forcing through it a series of plug gauges which gradually enlarged the opening and burnished it accurately to size. The carrying saddle was on ball bearings and provided with stops which insured accurate repetition of "open" and "closed" positions, 180° apart.

To establish proper alinement, the aper-

ture dd' was first adjusted in height and direction so that the transmitted beam would pass centrally through the window, W, of the pressure tank and along the central axis of the ionization chamber. This adjustment was not at all critical. The plug gauge, finally used, was then re-inserted in dd', fitting snugly and reaching through the

FIG. 3. Diagram showing the passage of radiation through the edges of the diaphragm.

radium carrier tube, cc', which was then fixed in its position by filling the tank, A, with shot. The alinement of $\mathcal{J}$ simply required correct "open" and "closed" positions.

On removing the plug gauge, inserting the radium and shifting the screen, N, into place, the set-up is ready for making measurements. The time required to effect this alinement does not exceed fifteen minutes.

It is particularly important when dealing with highly penetrating radiations that, in the operation of the shutters, the stray radiation field is not changed. The rotary type of shutter here used fulfills this requirement. It was found that by using the collimating and screening system as described, the background radiation did not exceed 4 per cent of that of the direct beam, and by inference, the error introduced by the quantity passing through the "plug" alone was negligible. This low background radiation was no doubt responsible for the low-shielding requirements around the electrometer system mentioned above.

With the type of collimating system here used, there will of course, be a small amount of radiation transmitted through the edge of the diaphragm at the exit end of the orifice owing to the obliquity of the rays from the outer parts of the radium source (see Fig. 3). The relative magnitude of this effect will decrease with increasing distance, F, between radium and diaphragm. Calculations were made for such leakage by dividing the exit face of the orifice into narrow concentric zones and then computing the transmission of each. The results given in Table I are the maximum and the actual transmission may possibly be less by as much as 10 per cent. Since most of the other measurements were made at $F = 62.5$ cm., a 2 per cent correction only was applied.

Since the thickness of the diaphragm, dd', is not small compared with its distance from the source of radiation, and since its wall is not perfectly opaque, the question arises whether or not the aperture at d' is, as for the ideal case, the limiting

TABLE I

TRANSMISSION THROUGH EDGE OF DIAPHRAGM IN PERCENTAGE OF UNOBSTRUCTED RADIATION

F	Per Cent
50 cm.	2.7
60 cm.	2.2
65 cm.	1.8
70 cm.	1.7
75 cm.	1.6

aperture for determining the quantity of ionization. For ideal conditions and all radiant points sufficiently close to the axis of the system, and sufficiently close to a fixed distance from the end, d', the quantity of direct radiation passing through the diaphragm varies inversely as the square of the distance of the source from d'. The quantity of the radiation reaching the ionization chamber from the inner walls of the aperture is negligible and that passing through the edges of the diaphragm is given in Table I. Of course, the radiation originates from an extended and not a point source, but as long as the diameter of the source is small compared to the distance, F (1:70 in our case) and is smaller than the diaphragm diameter, the inverse square law may be expected to hold.

To test the question, ionization chamber measurements on the transmitted radiation were made with the radium at a series of positions within its collimating tube, cc'; that is, at different distances, F, between

the radium and the exit face, d', of the diaphragm. Corrections to these measurements were then made from Table 1, and the results plotted against the inverse square of the distance—in Figure 4. The plotted points fall very closely on a straight line through the origin and thus justify the assumption that the limiting aperture is at the exit face of the diaphragm; and also assure the practical correctness of the calculated magnitudes of Table 1.

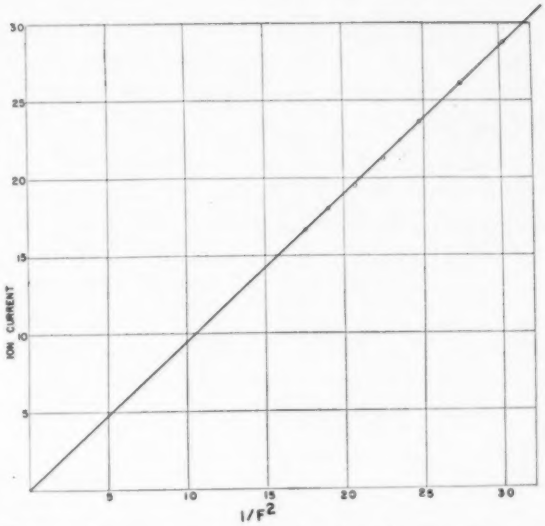

Fig. 4. Inverse square law plot for distance between radium and diaphragm edge.

IV. SATURATION

With the requisite plate spacing of about 30 cm. and a pressure of 10 atmospheres, saturation voltages are expected to be high, and in fact saturation is not completely obtainable because of columnar recombination at this pressure. Figure 5 shows a current-voltage curve of the ionization chamber under such conditions. There is no evidence of saturation at the highest field strengths, 670 volt/cm., corresponding to the applied potential of 2×10^4 volts. This condition is expected because it corresponds to only 67 volt/cm. at 1 atmosphere, which is barely sufficient to produce saturation at that pressure, even neglecting columnar recombination. Applied potentials above 20 kv. could not, however, be used because the resulting unsteadiness exceeded the permissible limits.

The possibility of applying Jaffe's theory of columnar ionization for extrapolating to saturation conditions was suggested by our earlier work on the roentgen-ray ionization of liquids,[15,19,20] and later work by Zanstra[22] and by Clay and his coworkers[2,6] who have applied it to gases from 20 to 400 atmospheres. Their findings have been further verified by Broxon and Meredith[1] with high pressure cosmic-ray ionization chambers.

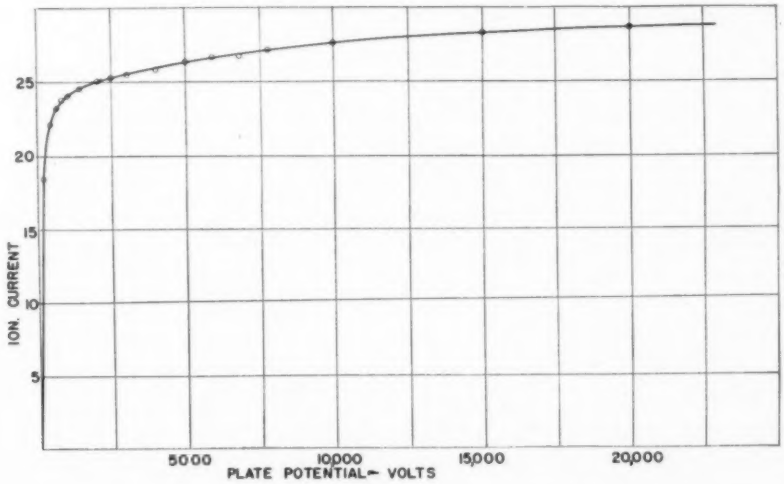

Fig. 5. Saturation curve at 10 atmospheres.

Zanstra gives the following relation between the current i and the saturation current I:

$$\frac{1}{i}=\frac{1}{I}+\frac{q}{I}f(x) \tag{1}$$

where

$$\frac{q}{I}=\frac{\alpha N_0}{8DI} \tag{1a}$$

in which N_0 = number of ions per cm. path length,
D = diffusion coefficient,
and α = recombination coefficient.
$f(x)$ is a Hankel cylinder function of the form

$$f(x)=e^x\frac{j}{2}H_0^{(1)}(jx) \tag{2}$$

where

$$x=c\cdot\left(\frac{X}{p}\right)^2 \tag{3}$$

in which X is the field strength, p is the pressure in atmospheres, $j=\sqrt{-1}$, and for air, $c=1.24\times10^4$.

Figure 6 gives a reproduction of Zanstra's curves $f(x)$ versus X for the range of $x=1$ to 10^{-6}. A plot of $1/i$ versus $f(x)$ for different values of X should, by equation (1) give a straight line for which the intercept on the $1/i$ axis is the reciprocal of the saturation current I. It should be noted that the constants in equation (1), and the approximations in the theory do not directly influence the value of $1/i$ but serve to rectify the curvature which would otherwise appear in a simple plot of $1/i$ versus $1/X$.

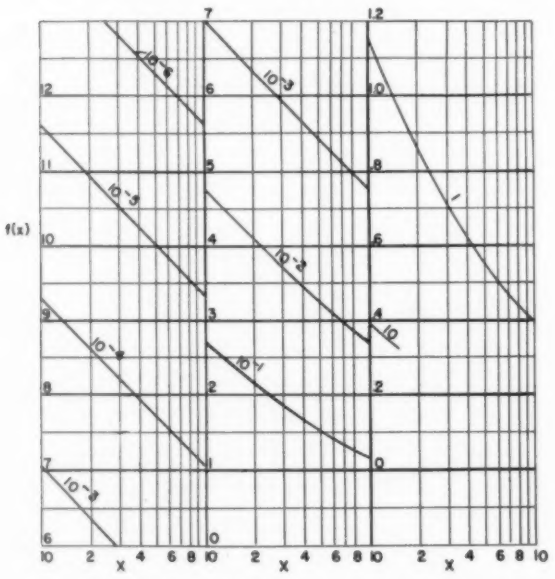

FIG 6. Zanstra's curves for evaluation of $f(x)$.

The validity of the Jaffe-Zanstra theory was tested in the present work by measuring a fixed 300 kv. roentgen-ray beam at pressures of 1.0, 6.80, and 10.13 atmospheres, respectively. In the ionization chamber, a plate separation of 30 cm. was used, so that no wall correction was necessary at any pressure. Figure 7 shows the current-voltage curves at 1 and 10.13 atmospheres (coordinate scales to right and top) and the $1/i$ versus $f(x)$ (scales to left and bottom) for 10.13 atmospheres. The intercept of this $1/i$ plot and a similar plot of 6.8 atmospheres gave the following values of I after correction for air absorption: I (10.13 Atm.)/10.13 = 1.076; I (6.8 Atm.)/6.8 = 1.078 and I (1 Atm.) = 1.078. The agreement is better than the experimental error of about ±0.5 per cent in the particular measurements warrants. These measurements were made with a maximum of 8,000 volts on the plate (field strength = 27 v/cm·atm.).

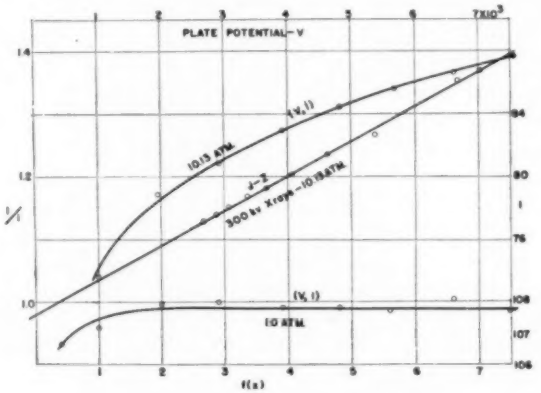

FIG. 7. Normal saturation and Jaffe-Zanstra plots at 10 atmospheres.

It was of course necessary to see if the measurements made at field strengths between 3.3 and 27 v/cm·atm. formed an

adequate basis for extrapolation or if higher fields were required. Figure 8 shows the $1/i$ versus $f(x)$ curve obtained from the data plotted in Figure 5. Here it is evident that it is not necessary to exceed the field of 270 v/cm. at 10 atm. or 27 v/cm·atm. although by going to fields as high as 67 v/cm·atm. the extrapolation is somewhat shortened. Under the particular conditions at 27 v/cm·atm. the current is 87 per cent of the saturation current, I, and at 67 v/cm·atm. it is 94 per cent.

The extrapolation, therefore, amounts here to about 6 per cent of the total length, as compared with values as large as 45 per cent for higher pressures and the higher fields used by Clay[2,3,6] and Broxon and Meredith.[1] (Reduced to atmospheric pressure their field strengths were usually much smaller than ours.) By decreasing the plate separation to 18 and 7 cm., the maximum field strength was increased to 45 and 80 v/cm·atm., respectively, and the maximum measured current was 96 per cent and

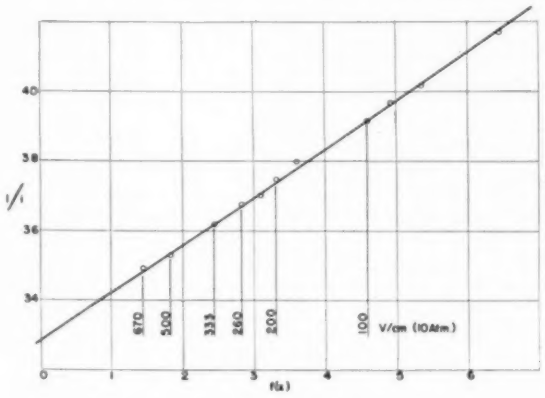

FIG. 8. Jaffe-Zanstra plot for field strengths up to 670 v/cm.

97 per cent, respectively, of the saturation value obtained by the J-Z extrapolation.

The chamber was not usable for our purposes under these conditions since the decreased plate separations would introduce undesirable wall effects. The results indicated, however, that the J-Z plot would be linear to within at least 3 per cent of the saturation current value and hence the extrapolation used with wider plate separations is similarly justifiable.

For convenience it is frequently desirable to make comparative measurements without, for each condition, going through the entire J-Z extrapolation procedure. Such a procedure is permissible under conditions (1) where the ionization density does not vary over too wide limits or (2) where measurements are well inside the region where the J-Z curve is linear and the field strengths do not differ too greatly or (3) both.

A check of the first point was afforded in testing the validity of the inverse square law plot of Figure 4. The points on this plot were obtained at a fixed field strength of about 26 v/cm·atm. giving a value for $f(x)$ of about 3. To check their validity, complete J-Z extrapolations (Fig. 9) were made for two distances between the radium and the exit face of the diaphragm, such that the edge correction for the diaphragm should be practically negligible between the two positions. From the J-Z computations the saturation value for 61.0 cm. is .0273 and for 73.8 cm. is .01865. The ratio $\frac{.0273}{.01865} = 1.464$ should, if the theory is applicable, be that of the ionization produced in the two cases which in turn should be inversely proportional to the squares of the distance. This latter ratio is $\left(\frac{73.8}{61.1}\right)^2 = 1.458$

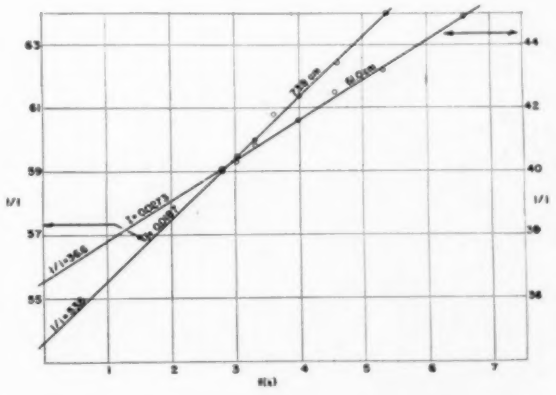

FIG. 9. Jaffe-Zanstra plots for different radium-diaphragm distances.

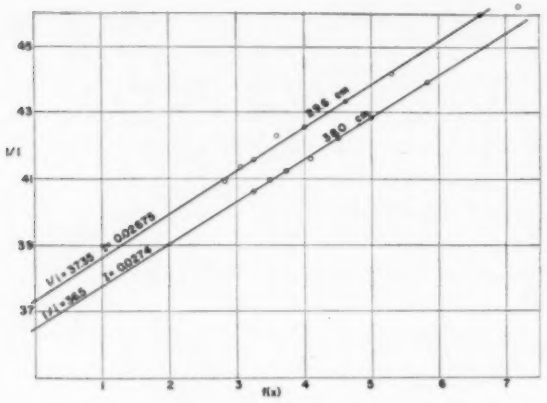

FIG. 10. Jaffe-Zanstra plots for different plate separations.

and agrees with the ratios of the ionization to 0.4 per cent, which is within the experimental error. It is clear from the plotted points (Fig. 9) that even with the poorest choice of the position of the intercept, the saturation value could not be in error by as much as 0.5 per cent.

The second point is illustrated by the curves in Figure 10 where two J-Z curves are drawn through points measured for the same beam (hence, same ionization density) but with different plate separations and hence, different field strengths. The resultant straight lines converge slightly so that the ratio of the two ordinates for any single value of $f(x)$ over the range of $f(x)$ shown, has the constant value 1.023. Similar ratios at a given applied voltage are very nearly 1.00. This divergence arises from the difference in field strengths and will be discussed later.

It should be pointed out that Zanstra's evaluation of Jaffe's equation fails for low field strengths so that the J-Z plot is no longer linear, the points falling above the extended straight line. The point at which this deviation begins is variable and depends upon the nature of the gas, pressure, ion density and field strength. Under the conditions of this study the deviation begins for fields below about 2 v/cm·atm. or values of $f(x)>7$. The effect has been described by Clay and van Kleef as the condition where volume recombination begins to become relatively dominant in comparison with the columnar recombination.

V. EFFECT OF PLATE SEPARATION

In their gamma-ray measurements with a large open air guarded field ionization chamber, Kaye and Binks[11] found a plate separation of about 3.0 meters apparently sufficient to prevent the impingement of an appreciable amount of secondary radiation upon the plates. On this basis we have done much of our exploratory work with a separation of 30 cm. at a pressure of 10 atm., which is equivalent to Kaye's spacing.

However, to be certain that the chamber was free from wall effects, ionization currents were measured for different plate separations. For these, the beam width was about 2 cm. at the center of the chamber. Curve *A* in Figure 11 was obtained by simply increasing the plate spacing while keeping a fixed potential of 7,000 volts between plates. Saturation was apparently reached at about 30 cm. However, with increasing distance between the plates, there is a proportionate decrease in field strength; consequently the flattening of the curve, *A*, may be caused in part by the decrease in field strength. To eliminate this factor, the second curve, *B*, was obtained with the same field strength at all plate spacings.

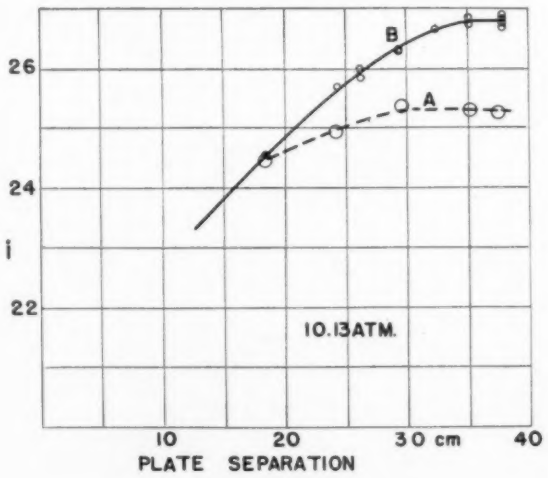

FIG. 11. Plate separation curves at 10.13 atmospheres.

In this latter case field saturation was not definitely reached below about 35 cm., which spacing, or one greater, was used in the final radiation measurements. These studies have shown the unreliability of comparing ionization measurements made under definite field strengths. Above about 2.00 v/cm·atm., comparisons at the same field strength are valid, provided the radiation intensities and qualities are about the same.

The results of the curve *B* in Figure 11 were checked by means of the J-Z extrapolation made at plate spacings of 29.6 and 38.0 cm. and shown in Figure 10. The ratio $I_{38}/I_{29.6}=\frac{.02740}{.02675}$ is 1.023 as compared with a ratio $i_{38}/i_{29.6}=\frac{26.8}{26.3}$ which is 1.019 (from Fig. 11) for the curves made at constant field strength.

Comparing these results with the work of others, a fairly good agreement is found with Kaye and Binks.[11] We find an ionization increase of only about 2 per cent by increasing our plate spacing from effectively 3 to 3.5 meters (30 to 35 cm. at 10 atm.), beyond which the change is not measurable. Failla and Marinelli[8] have shown the deficiency of the free air chamber used for gamma-ray measurements by Failla and Henshaw.[7] The plate spacing of 1 meter at atmospheric pressure used in the earlier work was insufficient. Mayneord's[13] plate spacing of 30 cm. at 1 atm. was clearly too small as he subsequently pointed out.

Two previous studies of gamma-ray measurement have been made with high pressure ionization chambers. Clay and van Kleef[4] used an argon filled chamber with metal grid electrodes 5 mm. apart, at fields from 100 to 4,000 v/cm. at 100 atmospheres pressure. (This was equivalent to 40 v/cm·atm.) Clay, Stammer and van Tijn[6] obtained with this chamber, by means of the J-Z extrapolation, a value for Eve's constant which is in reasonable agreement with other determinations. However, since their plates had an effective separation of only about 50 cm. at 1 atm., wall effects played some part in their result.

Friedrich,[9] and Friedrich, Schulze and Henschke[10] used air at pressures up to 139 atm. in a graphite chamber having an electrode separation of what appears to be 8 mm. in their drawing; but they took no account of columnar ionization. Their effective plate separation at 1 atm. was on this basis about 110 cm., hence, the measurements also involve wall effect.

VI. ELECTRONIC EQUILIBRIUM

To insure the accurate evaluation, in roentgens, of gamma rays, using a free air chamber, it is necessary to have what is known as a state of electronic equilibrium over the region from which the ions are measured. This condition is realized when the electrons which escape from the measuring volume under measurement are exactly compensated for by electrons which enter it from the outside space. Applied to the measurement of gamma radiation from radium by the free air ionization chamber, this requires that the volume from which the ions are measured be surrounded by an envelope of air having a thickness in all directions at least equal to the maximum range of the secondary electrons in those directions.

Where a narrow collimated beam of radiation is involved, this requires that between any limiting diaphragm or filter and the ionization chamber, there must be a free air path of a length at least equal to the longest paths of any scattered or recoil electrons. Since the secondary electrons involved in gamma-ray scattering are predominantly in the forward direction, a very considerable distance between the lead diaphragm *dd'* and the collector electrodes of the ionization chamber is required. Kaye and Binks[11] found that at atmospheric pressure a distance of 7 meters was apparently sufficient, whereas Friedrich's measurements[9] indicated about 15 meters. Using our equipment at 10 atmospheres, it was possible to test this over a range equiv-

alent to 6–21 meters at atmospheric pressure.

Following our earlier procedures,[21] ionization measurements were made for distances between the collector and the window over the above range. Inasmuch as the diaphragm was but 10 cm. outside the aluminum window of the pressure tank distances from the aluminum window to

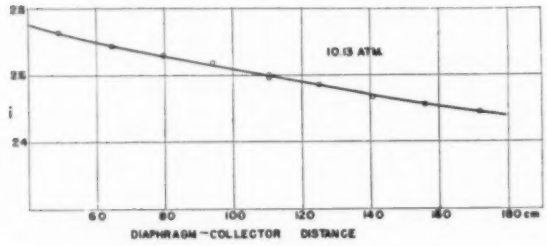

FIG. 12. Air absorption of gamma rays at 10 atmospheres.

the collector were used. Figure 12 shows the results of these measurements. It is seen that the decrease in ionization is linear within less than 0.5 per cent over the range of 70 to 150 cm. which is equivalent to a range of 7 to 15 meters at 1 atm. The small increase, above 150 cm. and below 70 cm., may be ascribed to scattering from the ends of the pressure cylinder. All measurements given in this paper were made at distances equivalent to 9 meters at 1 atm. unless otherwise noted.

It is clearly evident from the measurements in Figure 12 that a state of electronic equilibrium existed in the forward direction. From plate separation measurements of Figure 11, curve *B*, a similar state in the lateral direction is assured. However, a further check on these conclusions was obtained in trying to find Failla's "cloud effect."[8] Two sets of measurements were made at distances, *L*, between the collector and the window of 58.9 cm. and 120.1 cm., wherein the saturation currents were determined by the J–Z method. The ratio of the corresponding values of *I* was 1.023 as compared with a ratio of 1.027 derived from Figure 12 for the air absorption alone.

These measurements show the existence of electronic equilibrium within experimental errors but do not provide a fair test for the cloud effect. Since our minimum distance to the limiting diaphragm was about 6 meters, we may have been outside the region where any expansion of the cloud could be detected. Also, our collector having an effective length of 2.5 meters at 1 atm. any *small* change in the effect of the cloud shape would be masked. Any attempt to verify the effect at lower pressure would have been unreliable because then a state of lateral electronic equilibrium would no longer exist.

As indicated, the data in Figure 12 may be used to determine the air absorption for the radiation used. The absorption, which is found to be 7.7 per cent per meter at 10 atmospheres, requires that a correction be applied to all absolute measurements or all comparative measurements wherein *L* is changed; as, for example, the inverse square law measurements shown in Figure 4. The above value reduced to 1 atm. gives an absorption of 0.77 per cent per meter, in good agreement with the lower figure of 0.75 calculated from Kaye and Binks' work.[11]

VII. THE MEASUREMENT OF GAMMA RADIATION IN ROENTGENS

The magnitude of gamma radiation in roentgens has been variously defined in terms of the quantity of radium, time, filtration, and distance. In many cases, the literature has not been clear with regard to the various corrections applied in making the measurement, and this has resulted in confusion in the final results. We shall, therefore, risking repetition, describe in detail the various measurements and corrections employed in this study.

For reference purposes, the "emission constant," $\mathcal{Q}_0$, of radium is defined as the number of roentgens measured in 1 second at 1 cm. from 1 gram of radium, assuming the complete exclusion of any beta rays. This implies that the radium salt must be enclosed in a filtering container of known

gamma-ray absorption or by an air envelope of equivalent thickness.

In the radiological field, however, the quantity of gamma radiation, $\mathcal{Q}$, from radium is expressed as equal to the number of roentgens per hour produced by each milligram of radium, acting through 0.5 mm. of platinum, at a distance of 1 cm. from the radium. Since the radiation varies inversely as the square of the distance, the gamma radiation is then

$$\mathcal{Q}=r/D^2mT$$

where r is the number of roentgens at a distance of D centimeters from m milligrams of radium, in T hours. Here, the quantity of radium is taken as the actual mass of radium B and C in equilibrium with their disintegration products. The 0.5 mm. platinum filtration is added for the principal purpose of eliminating any beta radiation, and enters the experiment as a purely arbitrary factor for which no absorption correction is made. (Should correction be made for the absorption of the gamma radiation in the platinum the quantity result would be several per cent larger, and not expressed consistently with the radiological definition.)

The radium employed in this study was of the order of 500 mg. contained in a platinum cylinder 4.45 mm. long and 9.95 mm. outside diameter having walls 0.500 mm. thick. It was necessary to know the actual radium content for the proper evaluation of our results. The method of calibration is that uniformly used in the national laboratories of the various countries and has been recently described by Perry.[23]

Our radium was calibrated in the National Bureau of Standards radium laboratory under the supervision of L. F. Curtiss. The usual substitution method was employed, and he states that the measurements are believed to be accurate within 0.1 per cent. The electroscope was encased in a thick lead shield and hence differed markedly from our free air ionization chamber. The comparison was made against a number of individually calibrated radium preparations contained in thin glass tubes and bunched together so as to approach as nearly as possible the geometrical configuration of the preparation under calibration. By this means the absorption of radiation in the salt of the unknown and the comparison sources was made as nearly the same as possible and, therefore, balanced out. To test for this, the comparison tubes were arranged in a variety of reasonable configurations, and it was found that any calibration differences were negligible. The final result would not, of course, give the actual number of milligrams in the unknown, since the radiation from the latter was filtered by the additional 0.5 mm. of platinum, while that from the standard was measured after passing through the glass only.

The Bureau's certificate stated that the sample had a gamma radiation equivalent to that from 466.6 mg. of radium.*

Correction must be made, however, for the absorption of the emitted radiation in the salt itself (radium sulphate); because the amount of radiation finally emerging varies with the configuration of the salt. An absorption coefficient applicable to this problem was very kindly supplied to us by Dr. G. C. Laurence.† He gives a value of 0.037 cm^2/gram which he determined under experimental conditions comparable to ours. For making this test, he placed the radium salt in a funnel-shaped thin-walled tube. In one measurement the radium was spread thinly over a considerable area normal to the direction of measurement, and hence offered a negligible absorption of the radiation in the salt. In the second measurement, the container was inverted, so that the salt was packed in a long thin stem such that in its lengthwise direction a considerable absorption of the radiation took place. The absorption coefficient was

* Had the radium been contained in a thin-glass tube (as is used for the standards) its gamma radiation would have been 4.3 per cent greater than the certified value. (Under the conditions of calibration with a lead-walled electroscope, the platinum absorbed 4.3 per cent of the radiation.) Therefore, the *actual radium element content* of the preparation here used was 486.6 mg.

† National Research Council of Canada. Personal communication.

then derived from the difference between the two measured radiations.*

Assuming that, on the average, all the radiation is absorbed by only half of the radium content, an absorption value of 1.47 per cent is derived. This is in agreement with an integrated value since it must be assumed that there is no change in the quality of the radiation in traversing the salt—a not unreasonable assumption since the total absorption is so small.

Another absorption figure was supplied to us by Dr. G. W. C. Kaye.† For a cylinder of approximately the same diameter as ours but with 2.5 mm. inside length, he has determined a correction of 1.6 per cent which for our conditions would amount to nearly 3 per cent—a figure higher than any of those computed above. His work is expected to be published at an early date.

In the final calculations a correction of 1.47 per cent for absorption in the salt has been applied to the radiation from 486.6 mg. *actual* content of our capsule. We thus deal with an *effective radium content of 479.4 mg.* in the final result.

Although not very great, the correction for the absorption of the gamma radiation in the radium salt probably represents the largest uncertainty in our experimental results.

It should be emphasized that the 4.3 per cent platinum absorption correction in the original radium calibration applies only to the particular measurement technique employed by the radium laboratory. To make possible correction of our results to other platinum filtrations, separate platinum absorption measurements were made using the measurement technique described in previous sections. Successive layers of 0.10 mm. platinum foil were cemented lightly to the face of the capsule and ionization readings made with the back of the capsule always in the same position within the collimating tube (Fig. 2). The results, shown in Figure 13, indicate uniform absorption over the range of 1 mm. of added platinum. The linearity of the absorption curve would therefore indicate that under our conditions of measurement, the 0.5 mm. platinum wall absorbs approximately 7.2 per cent of the gamma radiation. This figure does not enter our calculations of $\mathcal{Q}$ since the filtration by 0.5 mm. of platinum is included in the definition, but does enter in the evaluation of the emission constant, $\mathcal{Q}_0$.

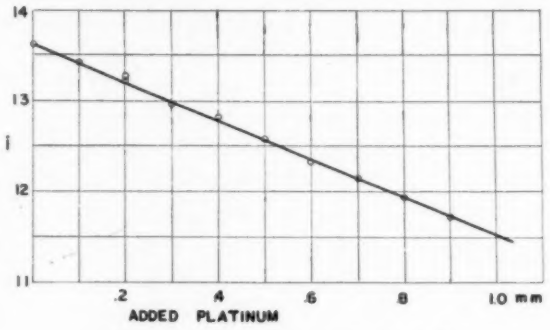

FIG. 13. Platinum absorption of gamma rays.

To obtain an estimate of the precision of the measurement, the errors in the several quantities involved in the determination of the emission constant of radium and the degree to which they enter the final results are listed in Table III.

TABLE III

ERRORS INVOLVED IN THE MEASUREMENT OF GAMMA RAYS

Quantity	Residual Error	Error in Result
Group A		
Radium calibration	± 0.1%	±0.1%
Salt absorption	20.0%	0.4%
Group B		
Air absorption	3.0%	0.2%
Diaphragm edge	10.0%	0.2%
Distance of radium	0.2%	—
Current measurement	0.3%	0.3%
Saturation current	0.3%	0.3%
Volume measurement	0.2%	0.2%
Pressure	0.3%	0.3%
Average deviation from mean in all observations	0.5%	—

* Laurence points out that absorption of the gamma rays in the source itself is complicated by the fact that we are dealing with the net absorption, which is a difference between the true total absorption and scattered radiation. The net absorption coefficient will be considerably lower than the more usually quoted coefficients which are total true absorption. Since the net absorption is so small, the effect on the absorption coefficient of any change in radiation quality is negligible.

† National Physical Laboratory. Personal communication.

TABLE V

SUMMARY OF THIMBLE CHAMBER MEASUREMENTS

Summary by	No. of Determinations	Average Value, $\mathcal{Q}$	Spread	Authors' Own Value
Mayneord and Roberts[13] (1934)	5	8.6	13%	8.3
Kaye and Binks[11] (1938)	9	8.0	17%	8.0*
Friedrich[9] (1938)	9	8.15	26%	7.8
Rovner[17] (1938)	12	8.55	15%	—
Laurence[12] (1938)	6	8.35	9%	—

* Free air chamber as well as thimble chamber.

The errors fall into two groups: (A) those involved in determining the effective quantity of radium, and (B) those involved in measuring the gamma radiation by our set-up.

In group A the calibration of the radium is accepted with the estimated possible error. Likewise, the residual error in the absorption by the salt lies in the uncertainty of Laurence's absorption coefficient.*

In group B also the residual errors in each measurement are as indicated. The average deviation from the mean in all observations did not exceed 0.5 per cent. The possible error in distance of the radium enters, because this is measured to the center of the capsule, whereas it might be argued that the distance should be measured to some other point. The residual error in deriving the saturation current is obtained from the greatest possible spread in the value of $1/I$ for $f(x)=0$ due to the choice of the straight line drawn through the plotted points.

The accuracy of measurement obtained by the square root of the sums of the squares of the individual errors in group B alone is ± 0.25 per cent and for both groups, A and B together, ± 0.28 per cent. Since the sum of the errors in group A is 0.41 per cent it is seen that the effect of the errors of measurement in the present work on the final result is negligible in comparison with the effect of the uncertainty in the quantity of radium and loss by self absorption.

In Table IV are given the various experimental values and apparatus constants involved in the measurement of gamma rays in roentgens.

TABLE IV

FACTORS IN THE CALCULATIONS OF THE EMISSION CONSTANT

Capacitance (C)	851 $\mu\mu f$
Compensating volts/sec (V/t)	1.791×10^{-2} (extrapolated value)
Distance (D)	62.0 cm.
Pressure (P)	9.67 atm.
Temperature (T)	302° K
Measuring volume (W)	19.60 cc.
Platinum absorption factor (k_p)	1.072
Effective radium content (R_e)	479.4 mg.
Air absorption factor (k_a)	1.081
Slit edge correction factor (k_s)	0.980

The following equation will give the emission constant, $\mathcal{Q}_0$, for radium B and C after allowing 7.2 per cent for the absorption of the radiation in platinum:

$$\mathcal{Q}_0=\frac{.9\times C\times V\times T\times D^2\times k_p k_a k_s}{300\times W\times t\times 273\times R_e\times P} \qquad (4)$$

$$=2.43\pm.01 \text{ r/g. sec. at 1 cm.}$$

In terms of the radiological unit the emission is $\mathcal{Q}=8.16\pm.04$ r/mg.hr. at 1 cm.

Various summaries have been made of the experimental values obtained for $\mathcal{Q}$ using thimble and other chambers, which

* Since a question of interpretation is involved in this correction, there is a possibility of as much as a 2 per cent error in the final result, depending upon the particular coefficient used. Use of any other probable coefficients will tend to increase the final value of the emission constant.

for comparison with our results, we give in Table v. In this, column 3 gives the number of separate previous determinations of $\mathcal{Q}$ which are averaged in column 4. Column 5 gives the maximum divergence between the averaged values. Column 5 gives the authors' own new value presented by each author in the same paper.

It is interesting to note that while the above summaries are based on essentially the same experimental sources, they vary over a range of some 7 per cent. This is because the different workers, in preparing the summaries, have had to correct the final results of the other workers for filtration or salt absorption and have used, for the purpose, differing correction factors. Other observers have weighted their summaries by discarding results which for one reason or another seemed questionable to them. This is, of course, a perfectly valid procedure, but it does show that the most probable value of $\mathcal{Q}$ is not to be had by a simple averaging of the various final results obtained in many different laboratories.

Our own value of $\mathcal{Q}=8.16$ r/mg·hr. at 1 cm. is about 2 per cent higher than the only other value obtained under free air conditions—8.0 r/mg·hr. at 1 cm. by Kaye and Binks. However, if we had used their value for the salt absorption, our result would have been still higher by about 1.5 per cent, and hence the disparity even greater.

Our own final values of $\mathcal{Q}_0$ and $\mathcal{Q}$ are presented with reservations as to the accuracy of the radium salt absorption correction, and further corrections may be made in the future. Further studies by experts in the radium field may yield a more accurate evaluation of this absorption coefficient.

VIII. CONCLUSION

The primary purpose of this investigation has been to investigate the possibilities of measuring the very short wave length radiation by means of a pressure ionization chamber. The results with gamma rays show that such wave lengths may be satisfactorily measured in roentgens so long as the pressure is sufficient to give an effective free path between the beam and measuring electrodes equal to the longest range of the recoil electrons. Since the ranges overlap those involved in roentgen-ray scattering up to 1.5 million volts, it may be concluded that roentgen rays up to at least 1.5 million volts may be measured in roentgens under free air conditions. It is therefore possible to directly calibrate thimble chambers against a free air standard for all excitations presently available, and thus provide a logical extension of the useful range of thimble chambers. Likewise, having once established a value for r/mg·hr. at 1 cm. it is possible to effect a direct calibration of radioactive preparations in terms of roentgens without further reference to the primary radium salt standards.

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FURTHER STUDIES ON THE RÔLE PLAYED BY CERTAIN NORMALLY OCCURRING INTRACELLULAR CHEMICAL COMPOUNDS IN GROWTH AND DEVELOPMENT*

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WHEN I received the invitation to come here, I was very much pleased, much honored and very glad indeed to come. I was given a choice of saying something about recent advances in cancer or almost anything in the growth field. So I have chosen to bring a certain specific part of some growth studies for your indulgence; it concerns the growth and development of a particular organism and the results of some chemical studies thereon.

I assume that I need say nothing more about this fact: that in order to study cancer, it is necessary to study growth. Ten or fifteen years ago it was necessary to emphasize that cancers were one part of the big problem of growth and development but I believe everybody realizes that nowadays. If we study growth and development in any kind of an organism, we are learning something about the big problem of growth and development and it will somehow or other have application to cancer.

Our particular interest in this study is this: Chemists tell us that inside of cells are large numbers of chemical compounds and they name a lot of them for us, so we have simply asked the question, "What do they do inside of cells in relation to growth and development?"

We have chosen such chemical compounds that we know are present in all living things, both animals and plants, so that we feel if we find out something about a particular group of chemical compounds which are present in all living things, we will have found out something which is applicable to humans or oak trees or to crocodiles or snapping turtles, to frogs or dogs or any other type of organism.

We do not speak, as a rule, of the living carbohydrate or living fat but we do say the living protein. The basis of protoplasm after all is protein material and we all know that proteins are made up of amino-acids as building blocks. There are some twenty-odd amino-acids that have been discovered, and amino-acids are alike inasmuch as they have carbon atoms with their four valences, one of which is taken up by the amino group, the other by the carboxyl group and a third valence by hydrogen. They differ in that one of the valences of a carbon atom is taken up by other groups. That is wherein they differ chemically.

Now if amino-acids have been evolved (and I believe chemical compounds are evolved) just to produce energy, i.e., to burn up and release energy, it would not have been necessary to have twenty-odd amino-acids; one or two could have done just as well.

Inasmuch as there have been some twenty-odd amino-acids evolved and they are all different chemically, it is logical to assume that each one has its own specific part to play in some of the activities of cells. We are interested in those activities which are connected in some manner with growth and development.

In order to study this phase of the situation, it was necessary to find some organism in which the various growth phenomena could be separated. There is growth in size, in number, in complexity; there is growth in specialization, there is even growth in intelligence, I suppose; so there are all kinds of different growths.

Obviously mammals cannot be used very well for such studies and so in the

* Read at the Twenty-Fourth Annual Meeting, American Radium Society, St. Louis, Mo., May 15-16, 1939.

Marine Experimental Station which we conduct at the end of Cape Cod, Dr. Hammett and his associates made a study of various organisms and hit upon a marine hydroid called *Obelia geniculata*.

They are colonial affairs. They grow on a stalk. This stalk attaches itself to a rock, a barnacle or a shell and then side branches come off from the main trunk and at the end of each of the branches there are these organisms.

One of the organisms is an ordinary somatic affair and it lives during a period of thirty-six to forty hours and then dies. Another one is called a gonophore and inside of that little bit, ova are produced, which turn into medusa, little jelly fish, and they are discharged into the sea water and float around. If they are lucky, they attach themselves to a barnacle and start a whole new organism going.

This organism, then, is born, goes through a period of childhood and puberty, young adult life, middle life, old age and disintegrates in a period of thirty-six to forty hours normally, and it is possible to separate all the different phases of growth in this organism and furthermore, it is possible to correlate these phases with metabolism.

The first thing that happens, of course, is that new cells are produced, and as these new cells are produced, chemical compounds are built into them. That is anabolism.

After the cells have been produced, it is necessary that they differentiate. They have to turn into covering cells and inside cells and so on. This is the phase which we call differentiation.

Then, finally, all these cells that are produced and differentiated have to gather together to form proper parts, and we call that phase organization.

Anabolism takes place up to the time the animal is produced and then there is a balance between the breakdown and building up, that dynamic equilibrium we call life.

Then when the organism undergoes degeneration, gets old and dies, catabolism is in the ascendency. That means that large molecules are broken down into a great number of smaller molecules.

All these things can be separated very readily in this organism. Some thirty-odd different phases of the growth process can be separately identified. To make a long story short, it has been possible to telescope the whole procedure so it goes through this whole process in about eighteen hours. It has been possible to spread out the period of middle life, to spread out the period of old age, to spread out the period of youth in this organism. In other words, to affect the various single and separate stages in the life cycle corresponding to certain stages in its growth and development.

This has, of course, nothing to do directly with cancer, you may say, and of course you are correct, but we must know what factors are playing a part in the growth and development of cancer as well as normal tissue and we must compare them. The only thing you can compare cancer to is normal growth.

Furthermore, Kogl's recent article shows the importance of these particular amino-acids and their rotation in the polariscope.

Then another thing which may be of direct interest to you is that many of these compounds accept irradiation of various kinds—with radium, roentgen rays and ultraviolet light—and as a result the atoms in the molecule are shifted around; oftentimes new compounds are formed. They may have exactly the same composition they had before but their atoms are rearranged in the molecule whereupon their physiological effects may be annulled completely or be exactly the opposite of what they were before they were irradiated.

As far as I know, this is the first time the complete life cycle of any organism has been filmed.

The technique was to have a motion picture camera sitting on top of a beam splitter and every fifteen seconds for forty hours or so, one frame was snapped and

then, of course, it was edited and a lot cut down. I have the privilege, then, of showing you this particular organism, this *Obelia geniculata*, and present it to you as an interesting and rather useful organism for the study of intracellular chemistry and for the study of the chemical factors

(The film was then shown.)

The main stalk of an *Obelia* is attached to a rock or shell or barnacle and side branches grow from this main stalk. At a local spot in the main stalk preparatory changes occur which show in a motion picture film as local activity of the granules

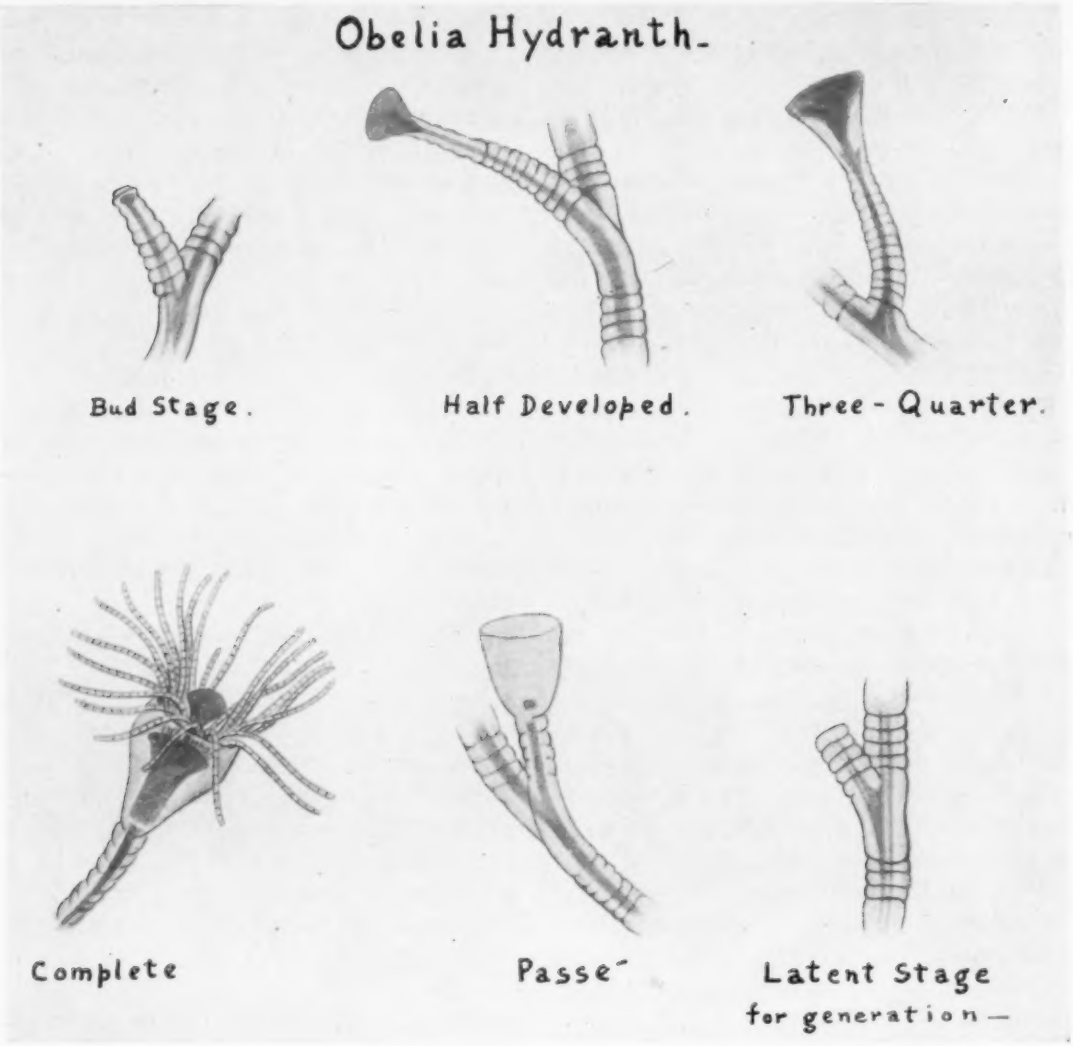

Fig. 1

which are involved in the growth and development of it, remembering all the time that these chemical compounds which we have studied are present in our own cells just the same as they are in the *Obelia geniculata* and we, in all probability, use them in a similar way.

of the protoplasm. This we call "initiation." At that point there then appears an outgrowth of tissue. The necessary chemical building blocks for this growth are obtained from the main stalk. Anabolism is in the ascendency corresponding to proliferation. Much pulsation and activity

is shown in this area. The animal has no heart, of course, and among the forces which cause this pulsation are changes in osmotic pressure; large numbers of small molecules are being built up into small numbers of large molecules. In an experiment when any particular chemical compound hastens this phase of the growth process we assume that it has effect on the proliferative phase of growth and on anabolism. As the shoot becomes larger its rate of growth slows, and we begin to see that its structure is not entirely uniform but differences appear in the different parts of the outshoot. This is differentiation. From the chemical side it means rearrangement of chemical molecules, atoms and groups from more general compounds to more specific ones, e.g., into those of epithelium. As time goes on there is less and less proliferation and more and more differentiation until there then appears a third process, namely organization, wherein definite structures begin to appear inside of the growing mass of protoplasm. When this process has reached a certain stage, much protoplasmic activity occurs and finally the tentacles of the animal which have been differentiated and organized, burst forth, begin waving in the sea water, and start their function of capturing prey. By the same logic, compounds which affect one or the other phases of these processes can be said to influence differentiation or organization. The completed animal now remains as such for several hours; neither catabolism nor anabolism is in the ascendency, there is maintenance metabolism in operation. Sooner or later, however, the organism begins to disintegrate, the tentacles turn inward and autolyze. Then large molecules are broken down into smaller ones which are returned to the stalk and catabolism is in the ascendency.

Thus, some thirty-two different types of growth reactions and metabolism correlations are possible in this animal. As a summary of the results of a few chemical functions:

Glycine accelerates regeneration.

Alanine has no apparent effect on the growth of the animal other than that which can be attributed to its specific dynamic action.

Phenylalanine may, as a potential source of tyrosine, forward differentiation.

d-Glutamic acid hastens differentiation and organization.

Tryptophane retards catabolism and thus may indirectly stimulate general growth.

Histidine may act similarly through its sustaining effect on metabolic expenditure.

Uracil favors recurrent growth and retards differentiation, regeneration and metaplasia.

d-Arginine has an effect similar to that of uracil, which suggests the latter as a natural precursor of the former.

d-Ribose has no specific effect on any of the developmental growth activities.

Allantoin might favor growth in general but it has no specific influence on increase in cell number.

dl-Methionine stimulates proliferation. Results are consistent with the assumption that methionine may be converted to cystine in the living organism.

l-Aspartic acid is specific for differentiation.

d-Lysine is essential to mass increment by participating in some intermediary process.

Thymine is significant in proliferaton and differentiation.

Cytosine helps differentiation.

l-Hydroxyproline accelerates proliferation and differentiation.

l-Proline forwards differentiation and retards proliferation.

Adenine enhances organization and retards initiation.

Xanthine forwards regeneration.

Guanine forwards initiation and organization.

From these results we may generalize a bit and state that each one of these amino-acids and of the nuclear compounds tried has its own specific part to play somewhere,

somehow, in the cycle of growth and development.

What cancer tissue does we do not know, but these data from normal growth seem essential as a basis of comparison when once similar studies can be done on cancer. The very means of diagnosis of cancer depends on this type of tissue having no organization at all, and perverted differentiation. Since we look at groups, molecules, atoms, electrons, etc., through the microscope when we observe cells it is obvious that the chemical makeup of the cancer cell differs from that of normal tissue. Some day, let us hope soon, some of this chemical knowledge of the growth of normal tissue will come in very handy in relation to cancer.

This work was done by Dr. Frederick S. Hammett and his associates at the Marine Experimental Station of the Lankenau Hospital Research Institute, North Truro, Cape Cod, Massachusetts. Photography of the *Obelia* was done by Prof. Lee Walp.

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Forty-first Annual Meeting: Hotel Statler, Boston, Mass., October 1–4, 1940.

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Twenty-sixth Annual Meeting: 1941, to be announced.

EDITORIAL

ON TO BOSTON

"ON TO Boston in October" should be the resolve of every member of the American Roentgen Ray Society, for there from October first to fourth will be held the Forty-first Annual Meeting of the Society at the Hotel Statler. The preliminary program was published in the July issue of the JOURNAL. A mere perusal of this preliminary program as outlined by President-elect Sosman and his committee will give some idea of the character of the papers to be presented. They have very happily included symposia dealing with various subjects; there is a symposium on the diagnosis and treatment of carcinoma of the larynx; one on classification, treatment and prognosis of carcinoma of the thyroid; one on unusual forms of pulmonary disease, and one on unusual gastrointestinal lesions and unusual sources of gastrointestinal hemorrhage. In the group of miscellaneous topics occur such subjects as: unusual intracranial foreign body; neuroblastoma; polyostotic fibrous dysplasia; planigraphy in diseases of the respiratory tract, and cranial laminagraphy. Among the clinical lectures to be given is an interesting one on "Roentgen Rays in Veterinary Medicine." These are just a few of the topics which have been arranged for presentation and discussion at the forthcoming meeting.

The Instruction Courses which were so popular last year at the Chicago meeting of the Society will again be offered and are again under the capable direction of Dr. B. R. Kirklin. The outline and abstracts of to courses to be given this year appeared in the May issue of the JOURNAL. The abstracts of these courses were published at an earlier date in order to permit those interested to make early application.

On Tuesday evening will be given the annual Caldwell Lecture by Dr. George W. Holmes. He has chosen as his topic "The Development of the Science of Roentgen Technique." This should prove of great interest to all roengenologists; particularly in these days when the diagnostic side of roentgenology has made such rapid strides one is apt to forget a very important feature, namely, technique in the practice of roentgenology.

Not only have the Program Committee arranged for the scientific side of the meeting but they, together with the various local committees, have made plans for many interesting social events. On Monday, September 30, the annual Golf Tournament will be held at the Commonwealth Country Club. The course is available for play all day. Luncheon and dinner will be served at the club and non-playing members are welcome at the dinner. Wednesday evening has been left free for members to make whatever arrangements they wish. On Thursday evening will be held a reception to members and guests by the New England Roentgen Ray Society followed by the Annual Banquet and entertainment and dancing. A splendid program has been arranged for the ladies attending the meeting and it is urged that the members bring their wives and others of their family. A detailed account of the ladies program was published in the August issue of the JOURNAL. Boston always offers an excellent opportunity for sight seeing, with its innumerable museums and historical associations, but particularly is this true at this time when that portion of the program is in such capable hands as the local Ladies Entertainment Committee composed of Mrs. M. C. Sosman as Chairman, Mrs. P. F. Butler, Mrs. Richard Dresser, Mrs. A. O. Hamp-

ton, Mrs. H. F. Hare, Mrs. G. W. Holmes and Mrs. Robert G. Vance.

The Scientific Exhibit Committee has made ample provision for the display of a splendid group of exhibits and these in themselves should be of great interest to members of the Society and guests.

Those responsible for the arrangement of the Technical Exhibit have been delighted with the enthusiastic response from the manufacturers and this year's exhibit will be the largest the Society has ever had. Here will be afforded an opportunity to obtain with little effort a thorough view of the latest developments in radiological equipment.

The details not possible to give in this brief survey of the coming meeting of the American Roentgen Ray Society will be found in the following issues of the Journal: *May* for Instruction Courses; *July* for Program of Scientific Sessions; *August* for Local Committees, Golf Tournament and Ladies Program.

Boston is an ideal meeting place and the facilities of the Hotel Statler have been placed at the disposal of the Society which should guarantee a perfect setting. As has been pointed out in the preliminary discussion of the program, Boston in the month of October is apt to have perfect weather which should add tremendously to the pleasure of those in attendance. No member of the Society can afford to miss this meeting and it is urged that those who have not yet made their reservations at the Hotel Statler should do so without delay.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. C. B. Peirce, Royal Victoria Hospital, Montreal, Canada. Annual Meeting: Hotel Statler, Boston, Mass., Oct. 1–4, 1940.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Next annual meeting: 1941, to be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1941, to be announced.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Cleveland, Ohio, Dec. 2–6, 1940.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets twice annually in May and September.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

RADIOLOGICAL SECTION, LOS ANGELES CO. MED. SOC.
Secretary, Dr. Wilbur Bailey, 2007 Wilshire Blvd., Los Angeles, Calif. Meets on second Wednesday of each month at County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. L. J. Taormina, 1093 Gates Ave., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary-Treasurer, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. C. J. Challenger, 3117 Logan Blvd. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. H. A. Mahrer, 10515 Carnegie Ave. Meets at 6:30 P.M. at Mid-Day Club rooms on fourth Monday each month, October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. P. R. Weeks, 520 Republic Bldg., Denver, Colo. Meets third Friday of each month.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

FLORIDA STATE RADIOLOGICAL SOCIETY
Secretary, Dr. J. N. Moore, 210 Professional Bldg., Ocala, Florida. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meetings held quarterly, on the fourth Sunday of the month.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. C. C. Taylor, 23 E. Ohio St., Indianapolis, Ind. Meeting held the second Sunday in May annually.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. J. C. Bell, 402 Heyburn Bldg., Louisville. Meets annually in Louisville on third Sunday afternoon in April.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. J. E. Lofstrom, 1536 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. I. I. Cowan, Mt. Sinai Hospital, Milwaukee, Wis. Meets monthly on first Friday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. A. O. Hampton, Massachusetts General Hospital, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. W. J. Marquis, 198 Clinton Ave., Newark. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. E. J. Ryan, St. Luke's Hospital, New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

PACIFIC ROENTGEN SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport Pa. Meets annually.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

PITTSBURGH ROENTGEN SOCIETY
Secretary, Dr. W. H. Jacox, 4800 Friendship Ave. Meetings held second Wednesday each month, 4:30 P.M., October to June at various hospitals.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. S. C. Davidson, 277 Alexander St. Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of October, January, March and May, at a place designated by the president.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. L. W. Baird, Scott and White Hospital, Temple, Texas. Next annual meeting, January 18, 1941, Sherman, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. C. H. Peterson, 603 Medical Arts Bldg., Roanoke, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday of each month at the College Club, Seattle.

Cuba

Sociedad Cubana de Radiologica y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1, England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive for scientific discussion.

Canadian Association of Radiologists
Secretary, Dr. A. C. Singleton, Medical Arts Bldg., Toronto, 5, Ontario.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext., Halifax, N. S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134 Louvain (Belgium). Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel. Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, 11.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aertze.
Permanent Secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgengesellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the spring, and one in the fall.

Societa Italiana Radiologia Medica
Secretary, M. Ponzio, University of Turin, Prof. Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly on first Monday at 8 o'clock.

Polish Society of Radiology
Secretary, Dr. Jan Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St. Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen. Meets the second Wednesday of each month from October to July in Copenhagen, at 8'oclock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6:30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University. Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

BULLETIN OF THE INTER-SOCIETY COMMITTEE FOR RADIOLOGY*

May I first express my appreciation of the honor you do me in granting me a place on your program and then as a surgeon pay a brief tribute to your specialty, without whose aid surgery would lose much of its accuracy. The practice of holding annual meetings at which the advances of the year are presented is evidence of a desire not only to recognize such accomplishments but to encourage those of present and future generations in their efforts to further the advance of medicine. The science of roentgenology has developed within the memory of many of those present, certainly within my memory, and as yet its rôle in the medical firmament cannot easily be appraised; it is, I think, a safe prediction that any present evaluation of roentgenology in the science of medicine will, in retrospect, be found an under-estimation. The application of its science has made it an essential factor in diagnosis in a greater number of diseases than is true of any other method and this application is steadily becoming more comprehensive. Since the whole structure of therapeutics rests on accuracy in diagnosis, the importance of this fact cannot be exaggerated. Many of the most serious diseases, notably internal cancer, fail to give rise to any clinical signs or symptoms in their early stages, and frequently roentgenology makes recognition possible at a time when there is the most favorable situation for bringing about a cure. As a surgeon I have been impressed with the fact that the interpretation of the revelations of the roentgenogram and the fluoroscope and the evaluation of these findings as related to the clinical symptoms by the joint efforts of the roentgenologist and the clinician have done much to clarify the diagnosis of lesions and abnormalities involving every portion of the body. Taking the gastrointestinal tract as an example, I think it may safely be said that roentgenology has contributed more than any other factor to the advancement and perfection of our knowledge in this field. The roentgenologist will with experience find in the behavior of the stomach of the patient with duodenal ulcer certain suggestions as to what will be the most successful operation. When the patient has marked obstruction from duodenal ulcer, impairment of motility as shown under the fluoroscope suggests, or at least clearly indicates, that relief of this impairment is all that is necessary. When the stomach shows great hyperactivity, the operation of gastroenterostomy, which is so effective when an obstruction exists, does not bring about as satisfactory results, for it is this very hyperactivity that makes possible the development of recurrent lesions. The results of duodenal ulcer show it to be a disease that can be controlled in about 80 per cent of cases by the coördinated efforts of the roentgenologist, the physician and the surgeon. Duodenal diverticulum is an example of a condition that can be detected only by the roentgenologist, the symptoms being so vague that a diagnosis on clinical grounds is impossible. The early diagnosis of cancer of the stomach is made possible only with the assistance of the roentgenologist and any improvement in the operative cure of this malady is to be ascribed to the aid afforded by the roentgen ray. Again, in advanced carcinoma of the stomach, the cooperation of the roentgenologist, the clinician and the surgeon is essential in deciding whether or not the operation is worthwhile. Gastric ulcer is probably less common that carcinoma and the situation of the lesion, whether on the greater or lesser curvature, and its roentgenologic aspects are of the utmost importance in determining the treatment. Persistent and recurrent pylorospasm as revealed to the roentgenologist is an important contribution in its relationship to intragastric disease. One could take each and every part of the human body and multiply instances comparable to those just cited. The total number of radiologists is comparatively

* An address by Irvin Abell, M.D., of Louisville, Kentucky, before the American College of Radiology on June 12, 1940.

small, but your specialty is of ever-growing importance in all branches of medicine, uniting many interests by the wideness of its appeal. Its scope as a diagnostic aid has found its way into every branch of medicine and surgery and has become so useful as to be absolutely indispensable. Roentgenologists are in reality consulting diagnosticians possessing knowledge of roentgen anatomy, roentgen physiology and roentgen pathology upon whose findings the diagnosis must in many instances depend. It is trite to say to this audience that the interpretation of roentgen findings should be restricted to those trained in this work. The roentgen ray itself makes no mistakes, but the judgment of the interpreter is not infallible. As in all branches of medicine, the greater the experience the riper the judgment. Irradiation alone has become a successful and well established therapeutic measure against many affections, the radiologist thereby qualifying as an independent therapeutic specialist. There is still in some quarters a disposition to look upon the radiologist as a technician or medical photographer and to dispense his services on this basis. I know of no branch of medicine in which more expert knowledge is required, both as a physician and a physicist, before one may justly be designated as an expert therein. The six great radiologic organizations, the Radiological Society of North America, the American Roentgen Ray Society, the American Radium Society, the Section on Radiology of the American Medical Association and the American College of Radiology with the American Board of Radiology attest the standing and domain of this specialty and symbolize the advance of this branch of medicine. As a surgeon I pay my respects and congratulations and offer my admiration to you for the constructive results of your efforts. Particularly do I wish to congratulate you on your efforts to retain and maintain your professional status. The efforts which have been made to dispense your knowledge and experience as part of a hospital service are not only fundamentally wrong from an ethical viewpoint, but if tolerated and accepted, are but the entering wedge for the dispensation of all professional services on such a scale. The proponents of such schemes fail to make a distinction between the ethics of commerce and the ethics of medicine; the former is based on the amount of goods that can be sold in the market, the latter upon the welfare and the good of the community. Medicine fits into the entire broad field of economics as does the exchange of any other services or goods for services or goods. In recent years we have heard much of the "production of medical care," "consumption of medical care" and the "distribution of medical care." There is no such thing as the "production of medical care," unless we mean the birth, education and training of doctors. There is no such thing as its "distribution," unless we mean doctors attending sick people. There is no such thing as "consumption" of medical care, unless we mean persons being helped by doctors. In the fields of commerce such terms are apt. Costs of production are cut by mass methods of manufacture; costs of distribution are reduced by cooperative buying in quantity; consumption is increased by lowering the cost and the selling price of the product. When we apply such terms to medical care, we take the connotations along and assume that the subject matter is susceptible to the application of the principles which the terms imply, and that is not true. Human knowledge and intelligence cannot be dispensed in boxes or crates as a commodity; they simply do not fit into such a concept of economics. For example, the cooperative philosophy of reducing costs is based upon quantity purchasing and the elimination of the middleman. Medical care cannot be purchased in quantity. In the first place it is not "purchased" at all, it is employed. There cannot be any such thing as quantity in a personal relationship; there can be quality but not quantity. Can 100 roentgen examinations be ordered today and delivered tomorrow? If so, to whom? And may the so-called "consum-

ers" reject them on a money back guarantee, if they do not like them? Can time elements in treatment be computed and a system of cost accounting evolved? Are the hospitals to determine the value of your services to them and then profit by the sale of such? If so, then we will have middlemen to our everlasting confusion. Any attempt to make the method of reward or financial gain, either to patient, physician or lay administrator, the basis of the organization of medical service, with domination of these considerations over the giving of medical service, or that seeks to produce and distribute such service according to competitive standards of cheapness backed by salesmanship methods violates the fundamental principles of medical ethics and invites the medical profession to surrender its ideals and to perish. The Principles of Medical Ethics have been criticized by lay people and even by some members of our profession as obsolescent and antiquated. It is readily admitted that the underlying principles are ancient, having been enunciated in the Hippocratic Oath written years before the birth of Christ, but it is submitted that the age-old principles are the only ones, whether in the ethics and economics of medicine or industry, that have stood the test of time. These Principles contain the self-imposed obligation of the profession to give of its service to those unable to pay and the implication that those in the lower income levels obtain service at a cost they can afford to meet. Many of the component units of the American Medical Association are at present engaged in experimenting with plans designed to bring service to these groups. These efforts deserve the support of such bodies as the College of Radiology to the end that the advantages and blessings of scientific medicine may be made available to all the people and that the service afforded will be good service, in other words, of uniform quality, not superior for one group and inferior for another. The social trends of American medicine are in harmony with its long established principles and policies which are directly concerned with the welfare of the public. Whatever plan is proposed in regard to medical care is automatically tested and accepted or rejected in relation to its influence on the morbidity and the mortality of the community affected. Reward or financial gain is to be a subordinate consideration. While good medical service cannot be expected unless society appreciates it sufficiently to financially reward those rendering it, it is equally true that a profession that seeks first financial reward becomes commercialized in spirit and mediocre or negative in scientific attainment. To those of us who have witnessed the rise and development of your specialty has been accorded a great privilege, that of living through and taking part in a remarkable transition period in the fruition and development of the art and science to which we bear allegiance. Medical science has made greater progress during our lifetime than in any previous period. Much of the newer work has been created and practically all has been evolved since our student days. Beginning our careers in the waning shadow of one school of thought, that founded on clinical observation alone, we have witnessed the growth and development of modern medicine, seeing in this golden age the beautifully integrated structure built upon accurate, scientific knowledge. Remarkable advances and progress are being charted in every field, but the words of Dr. George Shattuck, uttered as far back as 1866, still hold true: "No one can deny or doubt that we have made and are making great advances, but the horizon opens before us as we go on, and the extent of the field becomes even more apparent than our progress." We of today in medicine have a noble heritage, being the intellectual descendants of all the great minds who have heretofore charted its course. Realizing our commitment to the traditions established by our forbears and our responsibilities to the background of the past, we salute an even more brilliant future.

THE CONQUEST OF LEPROSY

Since this issue of the JOURNAL contains an article by M. J. Oberdoerffer and D. R. Collier on "Roentgenological Observations in Leprosy" it was thought the following item, which appears in the August 23, 1940, number of *Science*, would prove of interest in this connection:

In 1927 my wife and I visited Dr. Douglas Collier and his wife, Dr. Mary Collier, at their mission station at Nan, Siam. We also went to Chiengmai, where Dr. J. W. McKean was in charge of the admirable institution for the care of lepers. These medical missionaries worked under the auspices of the Presbyterian Board, and we felt that their work was of the utmost importance to the country, and a credit to their American supporters.

The years have gone by, Dr. McKean has retired, and now lives in California; Dr. Collier has moved to Chiengmai, and taken up the work with the lepers. All this might not call for special comment were it not that at last after long years of investigation, it appears probable that leprosy may be actually conquered. The experimental work at Chiengmai, in its present form, was initiated by Dr. M. J. Oberdoerffer, a young German who had worked in Africa under the British Empire Leprosy Relief Association. It appeared that the eating of colocasia predisposed to the development of leprosy, apparently due to a toxic substance also found in partly decomposed fish. Using this method, it was found possible to cause monkeys to acquire leprosy, something which it had seemed impossible to do before. The conclusion was reached that injury to the adrenal glands was the more immediate cause of trouble and short-wave radiation was used to stimulate these glands, with satisfactory results. However, it was suggested that possibly the use of diphtheria antitoxin might be beneficial, as in diphtheria a toxin is liberated which damages the adrenal glands. In diphtheria, antibodies are formed, but this seems not to be the case in leprosy. When the work had reached this promising stage, Dr. Oberdoerffer, on account of poor health, felt obliged to leave Siam. Dr. Collier continued the work, now using toxoid instead of the old antitoxin. The results have been extraordinary, and Dr. Collier states:

In the use of toxoid and antitoxin we have a treatment which far exceeds any method yet known. Results are obtained in a few weeks, which formerly were seen only after months or years of treatment. While the early cases are less spectacular in response, all types seem to be benefited.

It is reasonably hoped to immunize the children and associates of lepers, and so in time eradicate the disease. All these matters are set forth in a paper just received, published in the *Journal of the Thailand Research Society* (Bangkok), February, 1940.

T. D. A. COCKERELL

University of Colorado

NEW RADIUM CONTROL INSTRUMENTS

Two new radium control instruments in portable form which promise to be of great value to hospitals employing radium or high voltage roentgen rays have been perfected at the National Bureau of Standards, the Department of Commerce announced today.

The development of these instruments, the Bureau pointed out, was made possible through a circuit for integrating pulses from tube counters, recently designed by Dr. Leon F. Curtiss, chief of its Radioactivity Section.

The first of the instruments is suitable for measuring low gamma-ray intensities, down to the equivalent of 0.1 microgram of radium. The second is a dosage meter for gamma rays which indicates dosage in terms of roentgens per day and in addition gives a visual and audible alarm when this dosage reaches the maximum permissible amount of 0.1 roentgen per day. It will also give warning of excessive general exposures whenever large sources of gamma radiation are present, as from radium, high voltage tubes, and cyclotrons.

VIRGINIA RADIOLOGICAL SOCIETY

The annual meeting of the Virginia Radiological Society was held at the Greenbrier Hotel, White Sulphur Springs, West Virginia, on July 29, 1940. The following officers were elected: *President:* Dr. Wright

Clarkson, Petersburg, Va.; *Vice-President:* Dr. Clayton W. Eley, Norfolk, Va.; *Secretary:* Dr. Charles H. Peterson, Roanoke, Va. Dr. Ross Golden of New York City was guest speaker and also conducted a round-table discussion. This Society meets annually in October, but the meeting this year was held earlier in order to coincide with the joint meeting of the Virginia and West Virginia Medical Societies.

NEW YORK ROENTGEN SOCIETY

At a recent meeting of the New York Roentgen Society the following officers were elected for the coming year: *President:* Dr. Henry K. Taylor; *Vice-President:* Dr. Roy D. Duckworth; *Secretary:* Dr. Eric J. Ryan; *Treasurer:* Dr. Paul C. Swenson; *Member of the Executive Committee:* Dr. Harry M. Imboden.

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DEPARTMENT OF TECHNIQUE

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AGAR JELLY IN ROENTGEN EXAMINATION OF THE STOMACH

By WILLIAM P. GILMER, M.D.*

CLIFTON FORGE, VIRGINIA

A NUMBER of new variations in method of roentgen examination of the gastrointestinal tract have been reported in recent years. These have added very materially to the accuracy of this type of examination. It is not within the scope of this discussion to review this work, but we purpose to report briefly still another variation in method which gives definite promise of value.

The experiments reported were made in an effort to develop a technique for producing roentgenograms giving a better view of the internal topography of the stomach. The method depends on two factors: (1) covering the gastric wall with a thin layer of contrast medium which is highly adhesive in character; (2) producing varying degrees of pressure from the inside by a soft, expanding, radiolucent mass. The apparent advantages of this technique over the previously advocated pneumorelief method include the following: (1) the soft mass tends to hold the opaque medium in place instead of allowing it to drip to more dependent areas; (2) the amount of gastric dilatation is easily and accurately controlled; (3) the reaction of the stomach wall to varying degrees of expansion can be studied; (4) the method is simple.

The technique used at present is as follows:

(1) Give the patient one teaspoonful of a barium paste which is highly adhesive in character.

(2) Prepare a jelly by adding 20 gm. of granulated agar to 150 cc. of water and heat until the agar has melted.

(3) Add to the melted agar four teaspoonfuls of corn syrup.

(4) Cool to 37° C. and add one-fourth of a cake of yeast, mixing thoroughly.

(5) Allow to stand, stirring occasionally, until the consistency is between that of a heavy syrup and a thin jelly. The proper consistency of this jelly seems to be an important factor in producing satisfactory results. Under optimum temperature conditions, such as are found in the stomach, the volume of this mass will increase about 100 per cent in twenty-five minutes.

(6) When the agar jelly has reached the proper consistency, have the patient swallow it, timing the procedure so that the jelly will be taken three minutes after the barium paste.

(7) Roentgenograms are made immediately, after fifteen minutes, and after thirty minutes.

Cases illustrating the use of the method described are given.

CASE I. A woman, aged thirty-eight, was referred for roentgen examination of the gallbladder and gastrointestinal tract. Cholecystography gave evidence of gallstones. The routine gastrointestinal examination was negative. An examination of the stomach made by the method described above was negative. Figure 1 shows a roentgenogram of this presumably normal stomach dilated by the yeast agar mixture.

CASE II. A man, aged forty-one, was referred for examination of the gastrointestinal tract. Roentgenoscopic examination under pressure gave rather indefinite evidence of a small niche

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Fig. 1. Case 1. Roentgenogram of a presumably normal stomach after dilation with yeast agar jelly.

Fig. 2. Case 11. A fleck of barium is noted in the small ulcer crater.

Fig. 3. Case 11. Roentgenogram taken after further expansion of the jelly. A fleck of barium surrounded by a halo of decreased density seems to be a constant finding in gastric ulcer when this method is used.

Fig. 4. Case 11. A photograph of the ulcer removed at operation. A very small shallow crater is noted.

Fig. 5. Case III. A fleck of barium surrounded by an area of decreased density is also seen in this case.

Fig. 7. Case IV. The reaction of the stomach wall to the pressure from within is noted. The uninvolved part expands readily. The section infiltrated by carcinoma gives evidence of rigidity.

on the posterior wall in the pars media near the lesser curvature. Routine roentgenograms made in varying positions showed no evidence of an ulcer. None of the findings usually associated with gastric ulcer were present. Roentgenograms made after yeast agar distention of the stomach have interesting findings. An immediate roentgenogram (Fig. 2) showed a small

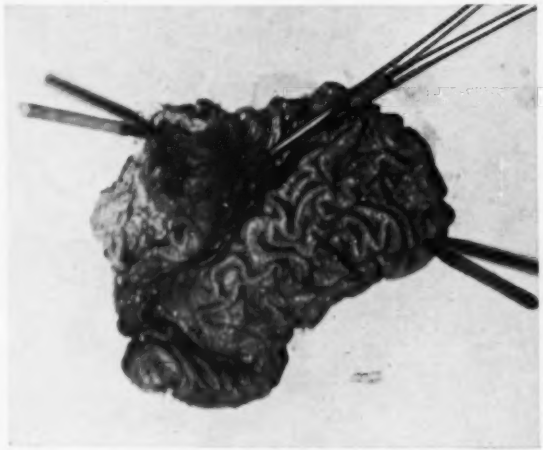

Fig. 6. Case III. This shows the ulcer located on the posterior wall of the stomach.

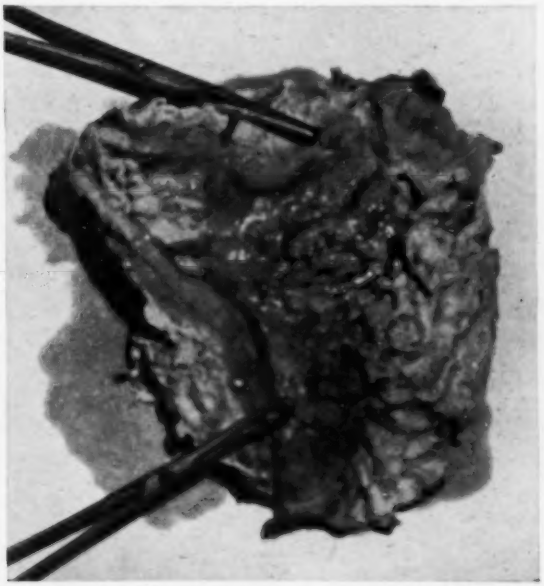

Fig. 8. Case IV. A photograph of the stomach removed at operation shows the extent of involvement corresponding to that indicated by the roentgenograms.

fleck of barium in the ulcer crater. A later roentgenogram (Fig. 3) after more expansion, showed the same barium filled crater surrounded by a halo of less density evidently caused by the partially denuded mucosa around the crater. At operation a very shallow ulcer was found in the location indicated (Fig. 4).

Case III. A man, aged thirty-nine, was given a routine roentgen examination of the gastrointestinal tract. Roentgenoscopically a small niche was noted on the posterior wall near the lesser curvature. This was visible under pressure with a small amount of contrast medium in the stomach. Roentgenograms made by the method under discussion showed findings similar to those described under Case II, a fleck of barium in the ulcer crater surrounded by a halo of decreased density (Fig. 5). At operation an ulcer crater was found in the position indicated by the roentgenograms (Fig. 6).

Case IV. A man, aged sixty-seven, was found by routine roentgen examination to have evidence of carcinoma of the stomach involving the distal one-half of the stomach wall. Roentgenograms were made after filling the stomach with the yeast agar mixture in an effort to demonstrate roentgenographically the limits of the involvement of the stomach wall. The involved portion remained fixed, while the remaining part expanded in a presumably normal manner under pressure from the yeast agar mass (Fig. 7). At operation a scirrhous carcinoma of the stomach was found and the involvement of the wall corresponded accurately to the roentgen findings (Fig. 8).

SUMMARY

A new method of double contrast roentgen examination of the stomach is described. It gives promise of accomplishing the following objectives: (1) a better view of the internal topography of the stomach; (2) roentgenograms which show evidence of gastric ulcer not brought out by previous methods; (3) accurate information as to the limits of involvement of the stomach wall by neoplasms.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

NECK AND CHEST

SPEDINI, F., and VALDINI, P. L. Contributo allo studio della pneumoconiosi da barite. (Study of barite pneumoconiosis.) *Radiol. med.*, Jan., 1939, *26*, 1–31.

The authors studied 50 cases of pneumoconiosis in workers in barite mills. They discuss the roentgen findings in different phases of the condition, both while the patients were still engaged in the work and after they had stopped for a period of eight years. They made roentgenograms of several workers who were engaged outdoors in crushing the large masses of ore into smaller pieces; no changes were found in the lungs in these men. But in the men who worked indoors at the crushing mills and in sacking the fine dust there were very marked changes which began early. The roentgen changes were out of all proportion to the clinical findings which were slight in the early stages.

In the first stage there was only an accentuation of the lung outline and a deafening of the shadows at the hilum. There were rarely any signs of pleural lesions or compensatory emphysema. Some authors have noted decreased motility of the inner half of the diaphragm which became more intense in the later stages. In the second stage the lung fields were more or less uniformly and symmetrically marbled; some of the spots were more or less miliary and others larger; these small nodules are probably caused by fibrous connective tissue, sometimes infiltrated with dust particles. They are particularly numerous at the margins and in the apices. The hilar shadows are larger and more marked than in the first stage and sometimes there is a moderate degree of emphysema in the lower parts of the lungs and bronchiectasis. The clinical symptomatology is still slight; only moderate cough with slight expectoration in the morning and dyspnea on exertion. The heart shadow begins to show changes in the right ventricle which tends to become hypertrophied. In other cases the form of the heart is that seen in asthenia, indicating atrophy of the walls of the heart. This is more common in the third stage. The third stage is characterized by sclerosis of the lungs and may present three forms: (1) confluence of the nodular foci in the form of irregular masses which may be separated by clear zones; (2) diffuse sclerosis with the presence of nodules which resemble those of tuberculosis; (3) massive sclerosis of the parenchyma in the form of large stripes passing from the hilum to the periphery, sometimes with extension of the process to the pleura; as a result numerous adhesions are formed especially of the base with the diaphragm, so that the excursions of the diaphragm are limited.

Five cases are described in active workers and 2 in workers who had discontinued the work eight years before examination. The details of the lung findings are given and illustrated with roentgenograms. These roentgenograms show that there was a gradual retrogression of the lesions in the cases in which work had been discontinued for some years.

This dust was 97.7 per cent barium sulphate with small admixtures of silica and iron. It was found that the lesions were caused by the barium sulphate itself and not by the admixture of silica. This form of pneumoconiosis does not tend to cause tuberculosis but rather acute forms of lung affection. There were no cases of tuberculosis in the material studied by the authors.

No measures of protection for the workmen were taken in the mills investigated by the authors. An effort is being made to bring about better ventilation of such places by the use of aspirators and to improve the masks made for protection from such dusts and encourage their more common use by laborers. The machines should also be protected so that the dust will not be so widely diffused through the air. The workmen themselves take little interest in such protective measures as the symptoms at first are slight and when the lungs do become affected they do not know the real cause of it.—*Audrey G. Morgan.*

DALL'ACQUA, V., and BELLI, M. La lobite media del polmone nelle sue caratteristiche radiologiche e cliniche. (Roentgenological and clinical characteristics of inflammation of the middle lobe of the lung.) *Radiol med.*, March, 1939, *26*, 171–197.

The authors review the anatomy of the mid-

dle lobe of the lung and give diagrammatic illustrations showing its boundaries and the variations that are encountered in different cases. As they studied only pathological cases they found considerable variations in the position of the lower border of the lobe. The anatomical conditions must be borne in mind in differentiating between lobitis and interlobar collections of fluid on the lower surface of the great incisure.

The authors describe 26 cases and illustrate them with roentgenograms showing the characteristic roentgen findings. Lobitis of the middle lobe cannot be diagnosed merely by physical examination; the latter must be supplemented by roentgen examination. However it is impossible to differentiate by roentgen examination alone between the different causes of such lobitis. This requires the aid of clinical examination. By far the most frequent form of lobitis is that caused by atypical pneumonia. Among the authors' 26 cases 20 were atypical pneumonia, 2 frank pneumonia, 1 chronic interstitial pneumonia, 1 abscess, 1 tuberculosis and 1 tuberculosis with ulceration.

In order to make a roentgen diagnosis, in addition to the roentgenograms in the usual projections one must be made in Fleischner's position of extreme lordosis, and also one in the laterolateral position. The typical picture in Fleischner's position is that of an isosceles triangle with a small base on the mediastinum and its apex toward the lateral wall of the chest. The chief conditions from which median lobitis must be differentiated are: interlobar pleurisy of the lower surface of the great incisure, mediastino-interlobitis, infiltrations of the lower lobe near the incisure and basilar blocks of infiltration. These different conditions are discussed and illustrated.—*Audrey G. Morgan.*

Ratti, Arduino. Eccezionale comportamento delle metastasi polmonari di un sarcoma. (Unusual course of lung metastases of a sarcoma.) *Radiol. med.*, March, 1939, *26*, 266–268.

The patient was a girl of twelve who came for treatment in July, 1936, for a tumor of the left thigh which apparently had begun five or six months before. A biopsy had been made in another hospital and the diagnosis was small-cell sarcoma.

The thigh was enlarged, the skin over the tumor stretched but not ulcerated; the scar of the biopsy had healed. Roentgen examination did not show any change in the femur or pelvis or regional lymph nodes. The patient's general condition was fairly good and physical examination did not show any involvement of other organs. A roentgen examination of the lungs, however, showed many round shadows of uniform intensity scattered over both lung fields, more numerous on the right. There was a large shadow of the upper part of the left hilar region. These findings were interpreted as being due to metastases in the lungs and in the left hilar region. Treatment was thought to be useless and the patient was discharged.

She returned at the end of October, 1938. She had had no treatment in the meantime. Her general condition was worse and the tumor of the thigh had increased in size. Inspection and palpation of the abdomen showed a tumor the size of a child's head in the left hypochondrium. It seemed to be due to metastases in the lymph nodes and liver.

A new roentgenogram of the lungs, however, showed that the shadows in the lung fields had entirely disappeared though there was an increase of the shadow of the left hilum. This led to a re-examination of the old roentgenogram to see whether possibly a mistake had been made in the interpretation of the findings there. No evidence of mistake could be found. Evidently the lung metastases had disappeared in spite of the progress in the primary tumor and the development of an abdominal metastasis. The cause of this is unknown.—*Audrey G. Morgan.*

Colosimo, Cesare. Xifosterno biforcuto e abnormemente lungo. (Bifurcated and abnormally long xiphoid process of the sternum.) *Radiol. med.*, Jan., 1939, *26*, 42–43.

This abnormality was found by chance in a man of forty-four admitted to the hospital because of suspected ulcer of the duodenum. Roentgen examination showed the first portion of the duodenum greatly deformed with a large niche. But all the roentgenograms showed to the right of the stomach an opaque shadow with the opacity of bone in the shape of a V open downward; the branches gradually grew smaller from above downward and ended in points at the level of the lower border of the body of the second lumbar vertebra. The branches were about 6 cm. long and their ends were free; at the upper end they united in a common trunk only about 1 cm. long. No continuity could be seen

between this common tract and the bones above it. The shadow of the common trunk lay in the middle of the long axis of the body and anterior to the spinal column: this was proved by the fact that in the right anterior oblique position it was projected to the left of the spinal column while in the left anterior oblique position it was to the right of the spinal column and immediately above the first portion of the duodenum.

The patient died of pneumonia followed by abscess. Autopsy showed the ensiform process bifurcated and of the consistency of bone. The right branch measured about 8 cm., the left was a little shorter. The lower ends showed no connection with the wall of the thorax, while the upper common part was connected with the sternum by a cartilaginous tract. The lack of calcium salts in this tract explained the invisibility of the upper end of the bone. The ensiform process becomes united with the sternum at the age of from fifty to sixty.

This anomaly is found occasionally on autopsy but the author does not know of any case that has been demonstrated roentgenologically before. And even on autopsy such cases are extremely rare.—*Audrey G. Morgan.*

GUBNER, RICHARD, CRAWFORD, J. HAMILTON, SMITH, WILBUR A., and UNGERLEIDER, HARRY E. Roentgenkymography of the heart; its clinical applications and limitations. *Am. Heart J.*, Dec., 1939, *18*, 729–746.

This study is based on a large number of normal individuals examined by a life insurance group and a variety of patients at the Kings County Hospital and the Long Island College of Medicine. A brief description is given of the method and apparatus. The areas on the cardiovascular silhouette most commonly studied and most easily interpreted are the greater portion of the left border of the heart representing the left ventricle and the region of the aortic knob representing the aortic pulsation. The left auricular pulsation on the left border is seen inconstantly and in a very small area. The pulsations on the right side are those of the superior vena cava and the right auricle and are usually difficult of interpretation. The complex factors producing even a simple pulsation and the distortion of movements occurring other than parallel to the slits is emphasized. The authors believe the most important application of kymography is in the demonstration of infarcts and they recommend that exposures be made in three projections. Changes are found in a high percentage of cases and localization corresponds well with the electrocardiographic findings. Infarctions are recognized by localized areas of paradoxical or abnormal pulsation. Considerable help is obtained in the diagnosis of myocardial aneurysms. This diagnosis is often missed on ordinary chest films, perhaps because the silhouette gives the diastolic shape of the heart while the deformity is best shown in the systolic phase. If there is cardiac enlargement great care must be exercised in interpreting changes occurring at the apex as they may be due to the myocardial dilatation and failure alone. A large heart may produce manifestations closely resembling those seen in pericarditis with effusion. Characteristic changes in the ventricular and vascular waves are described in the common valvular deformities. The difficulties in differentiation of aortic aneurysm and mediastinal tumor even with kymographic studies are emphasized.

In hypertension the aorta may have small waves because it is constantly distended by the high diastolic pressure. The waves of the pulmonary artery closely resemble those of the aorta; they are of increased amplitude in patency of the ductus arteriosus. If there is prominence of the pulmonary conus secondary to mitral stenosis the amplitude will be diminished because of the high diastolic pressure in the pulmonary artery. The conventional kymography is not well suited to the study of the arrhythmias because of the short observation period.—*W. A. Evans, Jr.*

ABDOMEN

BARBIERI, ARRIGO. L'indagine radiologica nell'-ascaridiasi. (The roentgen picture in ascaridiasis.) *Radiol. med.*, March, 1939, *26*, 197–225.

The *Ascaris lumbricoides* is one of the commonest parasites in the intestine of man. The author reviews its biological characteristics as related to roentgenology. When embryos are ingested they continue to develop in the human intestine and they may even migrate to the lungs, the brain or kidney. They are most frequently seen in subjects who are not very clean or who have occasion to come into contact with or to work in the earth. They are therefore more frequent in children and in agricultural workers than in adults or city dwellers. They are passed from the body with the feces or vomitus.

They may be rendered visible roentgenologically either with or without a contrast medium. In the latter case the gas of the intestine serves as a contrast. Fritz of Innsbruck first demonstrated ascaridiasis in 1922 and in 1923 Busi made the first Italian study of the subject.

With contrast medium the image of the ascarid is always negative. The author gives a contrast paste made up of 200 cc. water and 150 gm. barium sulphate and a little sugar or cocoa. Before making the examination with this paste the patient is given a few teaspoonfuls of a dense paste for a study of the folds of mucous membrane in the stomach. It is sometimes hard to demonstrate ascarids in a mass of liquid paste in the stomach. Before the examination with contrast paste the patient is examined without contrast medium in both the standing and recumbent positions. The exposure in this method of examination should be as brief as possible in order to avoid blurring of the image from movements of the parasites.

The roentgen image of the parasite may appear in the form of thin parallel lines outlining its body or in the form of an opaque line due to the presence of barium in the intestinal tract of the parasite itself. The length of these images may vary from 3 to 8 mm. The males are smaller than the females and the ends of their bodies are hook-shaped. Sometimes the parasites can be seen in the small intestine without any manipulation; in other cases it is necessary to manipulate the loops of intestine in order to distribute the paste and bring out the images. Moreover if there is any confusion with the valvulae conniventes or taenia the movement may separate the ascarids from the walls of the intestine so that the differentiation can be made. Sometimes the images of the ascarids are disc-shaped, in which case they may have to be differentiated from folds of the mucous membrane, papillomata or varices of the bulb of the duodenum. This can be accomplished by manipulating the ascarids away from the wall of the intestine. Papillomata and varices are also compressible while ascarids are more rigid. Differentiation from small round foreign bodies such as cherry stones and undigested peas may be necessary. These, however, are not accompanied by stripes due to defective filling as the disc-shaped ascarid images are. When there are large numbers of parasites sufficient to distend the intestine there are delicate opaque lines, parallel or in delicate spirals. Some authors have denied that the intestines of the parasites fill with barium but the author has demonstrated this experimentally. The images obtained were just like those seen in patients with ascaridiasis.—*Audrey G. Morgan.*

Benassi, Enrico. L'epatosplenografia col biossido di torio merita di venire completamente abbandonata? (Should hepatosplenography with thorium dioxide be completely abandoned?) *Radiol. med.*, Feb., 1939, *26*, 81–98.

Various objections have been urged to the method of rendering the spleen and liver visible by the use of thorium dioxide as a contrast medium. To be sure this method has not accomplished all that was hoped for from it, but the author believes, after further study, as he did in 1934 in his report before the Italian Congress of Medical Radiology that it still gives valuable results in certain conditions and that it is probably free of danger. It is true that modifications have been demonstrated in the cells after the use of this method, some of which were irreversible, but they can scarcely be called lesions, as no harmful action of the organs has ever been demonstrated. And no bad clinical effects on the patients have ever been reported even after the lapse of years by those who based their fears of its use on the histological findings.

The author reviews cases examined in this way in 1932, that is eight years ago, and in none of these cases has he seen any evidence of injury due to the thorium. In cases that were curable, cure was not prevented or delayed; some of these were cases in which the disease had already caused serious injury of the liver, as for example one case of severe syphilis of the liver. Some authors have claimed that the thorium method causes functional block of the reticuloendothelial system but the author has never seen decreased resistance to infection or any signs of change in the defensive function of this system. He believes it highly probable that the method does no harm, but admits there may possibly be some injury at a very long time after the examination because of the radioactive effect of thorium.

This method of examination, however, is of great value in certain conditions, as for example (1) in recognizing the size, form or position of the liver and spleen for diagnostic purposes, especially in differential diagnosis of tumors of the hypochondrium; (2) in demonstrating or excluding tumor metastases in the liver, for

diagnostic purposes or to establish indications for operation on other organs; (3) in suspicion of abscess or cyst of the liver, the diagnosis of which cannot be established in any other way; (4) in the study of the seriousness and the course of special cases of cirrhosis of the liver; (5) in studying step by step changes in the liver or spleen or diseases in them, with reference to the course of the disease and its treatment.

Berg, whose studies of the mucous membrane relief of the digestive tract are well known, has devised a new contrast medium for this method of examination which he claims is entirely harmless and has been proved to be so. It contains 50 per cent of the contrast substance, the formula for which has not been published, and 20 per cent of iodine. It can cause no late injury because it is eliminated quickly. It is to be hoped that this new method may become established in practice.—*Audrey G. Morgan.*

BERG, J. Zur Diagnose der "Kalkgalle." (Diagnosis of "calcium bile.") *Fortschr. a. d. Geb. d. Röntgenstrahlen*, October, 1939, *60*, 284–291.

The concept of calcium bile is rather unfamiliar to even experienced roentgenologists and clinicians. Only 8 cases have been reported in the German literature. The author reports another case, a woman, aged fifty-two, who first experienced colic and jaundice at twenty-two. She was examined because of symptoms of cholelithiasis and the preliminary film showed numerous gallstones in addition to an opaque fluid filling the gall bladder. With the patient upright, the fluid was seen to accumulate in the fundus of the gallbladder with the stones floating above. The same appearance was obtained following the ingestion of the dye for cholecystography. Operation revealed a slightly enlarged, chronically inflamed gallbladder. There were many adhesions at the neck but no stone was found in the cystic duct. The excised gallbladder contained 26 faceted cholesterin stones and a thick, gray-white homogeneous mucus mass. On standing in a test tube, a sediment appeared which proved to be calcium carbonate with traces of calcium phosphate and cholesterin. Other cases reported in the literature are reviewed. The cases are predominantly in adult females with a rather long history and with frequent attacks of colic. The gallbladder is always chronically inflamed and there is always obstruction of the cystic duct, either from stone, adhesions, or mucosal swelling. In the gallbladder itself there are always stones in addition to the calcium milk. The stones are for the most part cholesterin with a thin calcium envelope. The consistency of the "milk" varies from a thin milk-like fluid to a thick plastic mass. There is also in most cases a rather thin clear fluid, the so-called "white bile" which gives the fluid level in contact with the calcium bile. The bacteriological findings are usually negative although in the author's case an enterococcus was cultured. The calcium bile thus forms under conditions of aseptic stasis when the inflammatory exudate is rich in calcium.—*W. A. Evans, Jr.*

HEEREN, J. G. Das Röntgenbild der Kalkgalle und seine differentialdiagnostische Auswertung. (The roentgen picture of calcium bile and the differential diagnostic evaluation.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, October, 1939, *60*, 291–294.

The author presents the case of a woman, aged twenty-one, with right-sided abdominal pain for four weeks, which radiated to the right shoulder during aggravations. Palpation of the gallbladder region was very painful but no masses were felt. Later slight icterus appeared. The roentgen examination showed a homogeneous dense oval shadow 5.0×1.3 cm. in the right upper abdominal quadrant and with the patient upright a fluid level appeared with the more dense shadow in the fundus. Against the possibility of a large stone filling the gallbladder were the fluid level and the absence of all concentric or radiating striations, and in the absence of a history by ingestion of any contrast substances, the diagnosis of calcium bile was made. At operation the gallbladder appeared normal externally and its contents could be completely expressed by pressure. For these reasons the fluid could not be examined and the gallbladder was not removed. Roentgen examination fifteen days later showed complete disappearance of the shadow previously described.

Such cases reported in the literature have shown the gallbladder to contain a supersaturated calcium solution in which calcium carbonate crystals may be identified microscopically. In the majority of cases gallstones are present. Of the 12 cases collected by Knutsson, 9 had a stone impacted in the cystic duct. Volkmann (1925) is given credit as the first to describe this picture. In the differential diagnosis, a large solitary gallstone and calcification of the gall-

bladder wall must be considered.—*W. A. Evans, Jr.*

SKELETAL SYSTEM

Stein, Justin J. Bone metastasis from primary carcinoma of the lung. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 992–996.

Stein states the purpose of his paper is to stress the high incidence of bone metastasis from primary carcinoma of the lung, and second to report a case in which the site of the metastatic lesion was in the left superior maxillary bone. He found no mention of a similar case in the literature. Biopsy of the lesion in the maxilla showed metastatic adenocarcinoma. The lung lesion was found on roentgen examination in the lower portion of the right lung apparently in the middle lobe. Bronchoscopic examination revealed a bulging of the medial and posterior walls of the right main bronchus. The biopsy showed adenocarcinoma of the bronchus. The majority of cases of bone metastasis have been of the osteoclastic type. When cases of osteoclastic bone lesions are seen, carcinoma of the lung must be suspected as well as metastatic lesions from the breast, thyroid, kidney, and less frequently, from melanoepithelioma, ovary, and Hodgkin's disease.—*R. S. Bromer.*

Ratti, Arduino. Contributo radiologico allo studio delle metastasi ossee dei sarcomi. (Roentgen study of bone metastases of sarcomata.) *Radiol. med.*, Feb., 1939, *26*, 99–113.

The literature on bone metastases of sarcoma is quite scanty and it would seem that this form of tumor produces metastases in bone more rarely than carcinoma. The Mayo Clinic in 1932 reported 1,032 cases of bone metastases from malignant tumors, but all of them were from carcinomata. Not a single case resulting from sarcoma was reported. Other statistics showing the rarity of bone metastases from sarcoma are reported.

The author then describes in detail and illustrates with roentgenograms 8 cases of bone metastases from sarcoma which he has seen in the past ten years at the Radiological Institute of the University of Milan and the Radiological Service of the Victor Emanule III Institute for the Study and Treatment of Tumors. Of these 8 patients 6 were between the ages of fifteen and twenty, showing that sarcomata are more frequent in the young than in middle-aged and old persons. In 3 of these cases the primary tumor was in bone, in 2 in the sinuses of the face, in 2 in the lymph glands and in 1 in the prostate. The metastases were sometimes multiple; in 3 cases the vertebrae were affected, in 2 cases the ribs, in 2 cases the long bones of the limbs, in 1 the cranium and in 1 the scapula. In nearly all cases the metastases were in bones that were superficial and accessible to palpation.

The roentgen pictures showed not only the bone-destructive processes seen in metastases from carcinoma but also processes of apposition resulting in increased size of the bones. There was visible and palpable enlargement of the bones which is rare in carcinoma. Clinically, too, these metastases differed from those in carcinoma in that there was almost always pain that preceded by some weeks the possibility of roentgen demonstration of the tumors. These characteristics can be utilized in differentiation between metastases of sarcoma and carcinoma. —*Audrey G. Morgan.*

Dörr, Hans. Die Metastasen beim Genitalkarzinom der Frau, unter besonderer Berücksichtigung der Knochenmetastasen. (Metastases in genital carcinoma of the female with special reference to osseous metastases.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, October, 1939, *60*, 263–272.

Reports in the literature on the incidence of metastasis in carcinoma of the female genital organs show a great variation in opinion. The report of a large series of extensive carcinomas gave 49 instances of distant metastasis, of which 11 were in the lungs or pleura, 8 in the vertebral column, 6 in distant lymph nodes, 4 each in the skin and cerebrum, and 3 each in the bones, liver and stomach, 2 each in the kidneys, peritoneum, and ovary and 1 in the intestine. Most reports give a very low incidence of metastases to bone in uterine carcinoma and the author, in reviewing a thousand case histories from the years 1921–1931, was impressed by the absence of such metastases. Recent experience seems to call for a revision of this impression. Within one year 10 cases with metastases to various bones were encountered and this gave an incidence of 2 per cent in the cases which were seen. Of these 2 patients with pathological fractures through bone metastases have already been reported. Two women exhibited metastases in the calcaneus and talus.

When the patients complain of a circumscribed dull pain, examination should always be

made for a metastasis in the neighboring skeletal structures. Irradiation of early metastases arrests their growth and gives relief or alleviation of pain. The apparent increase in osseous metastases cannot be explained by the longer duration of the disease because of more effective treatment inasmuch as metastases may occur in the first year. The possibility that the trauma incident to large radium doses may disseminate metastases should be entertained.—*W. A. Evans, Jr.*

SHEHADI, WILLIAM H. Primary pyogenic osteomyelitis of the articular processes of the vertebrae. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 969–976.

The occurrence of pyogenic osteomyelitis of the vertebral column is considered to be relatively rare when compared with the incidence of the same disease in the other bones of the body, especially in the long bones. However, when the milder and more benign types, as well as the better recognized acute types and the many unrecognized cases, are considered, it will be found that the condition is not so very rare. The usual conception of osteomyelitis of the spine is that of a severe acute inflammation, often with cord involvement and nerve complications. Recent progress in roentgen technique and diagnosis has brought to light many cases of the milder and more chronic variety. These are referred to as a benign form with or without abscess formation.

The author reports a case in which after serial roentgenograms had shown no apparent involvement of the vertebrae, a sinus developed through which a small sequestrum was extruded. Roentgenographic examination then showed an absence of the right inferior articular process of the second lumbar vertebra, with destruction of the larger portion of the corresponding process of the third vertebra. Destruction was sharply confined to the parts mentioned and did not extend to the pedicles. There was no bone reaction. The bodies of the vertebrae and the intervening spaces were intact. No bone sequestra were visible.

The disease process was evidently connected with the skin lesion which was first present, a furuncle on the elbow. The loss of the articular processes and the consequent disappearance of the joint did not incapacitate the patient. It is possible that the initial focus started at the site of an ununited epiphysis of the mammillary process of the third lumbar vertebra and extended into the entire articular process with which it is intimately connected and practically fused. On the other hand, Shehadi thinks this case does not seem to be one of "accessory articular processes" or of secondary epiphyses of articular processes. He believes it must have been a case of primary involvement of the articular processes.—*R. S. Bromer.*

BATTS, MARTIN. The etiology of spondylolisthesis. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 879–884.

Batts states that it is a generally accepted teaching that spondylolisthesis is due to a congenital defect because of non-fusion of the centers of ossification of the fourth or fifth lumbar vertebra. It is a fact that in spondylolisthesis the responsible factor is a separation of the neural arch between the superior and inferior articular processes. He says, "it is not a fact that the separation of the neural arch is the result of a non-fusion of anomalous ossification centers; it is a conjecture."

To determine the incidence of anomalous centers of ossification in the lumbar vertebrae, Batts undertook a study of 200 fetal spines. He found that the formation of the "isthmus," or pars interarticularis, is not, as commonly supposed, at the junction of the two separate ossification centers of the vertebra. The formation of the isthmus is caused by the widening of the ossification center below that point, which, in turn, is due to the development of what is later to be the inferior articular process. The proposition may be made that spondylolisthesis develops on a congenital basis because of the inherent weakness at the isthmus of the neural arch, the isthmus being developed before birth. This is not, however, what is usually meant when reference is made to the congenital origin of the condition. In this sense, fractures of the neck of the femur might be assigned a congenital origin, because the neck of the femur is congenitally the weakest part of that structure. He concludes that the proponent of the congenital theory may be correct but the probability, based on mathematical calculation is extremely remote, and, whatever may be the etiology of spondylolisthesis, it is probably not based on a congenital defect.—*R. S. Bromer.*

ROBERTS, SUMNER M., and VOGT, EDWARD C. Pseudofracture of the tibia. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 891–901.

For several years the authors, at first inde-

pendently and later together have been interested in certain cases which have shown a rather unusual type of lesion in the upper third of the tibia. The patients all were children. The majority of the lesions were treated as fractures and yet they all showed certain characteristics which were very unlike the ordinary results of trauma. A careful study of their cases, 12 in number, disclosed features, quite common in occurrence, which led them to believe that the condition is a clinical entity, which so far as they have been able to discover, has been noticed but has never been fully described. Because most of the cases were considered fractures (erroneously they believe) they have given the name "pseudofracture of the tibia" to the condition. They suggest that further study may warrant a more accurately descriptive name.

Age incidence in their patients ranged from four to sixteen years. In all of the patients the same area was involved, namely the upper third of the tibia, a few inches below the epiphyseal cartilaginous plate. The chief symptom was slight to moderate pain at the site of the lesion accompanied by a slight limp. In only one case could a history of trauma be elicited. Three of the patients had evidence of a recent infection elsewhere in the body, a septic sore throat, a furuncle, and osteomyelitis.

The roentgenographic findings were those of a low grade infection and their character depended on the time when the examination was made. If the patient was seen early, there was just a slight periosteal thickening on the posterior aspect of the tibia, hardly discernible in the films. In the course of a few weeks' time, this periosteal thickening became more evident. Beneath the periosteal new bone, what seemed to be a break in the cortex developed, closely resembling an incomplete fracture line. Subsequent films showed that this line became more distinct and it often extended transversely in an irregular manner to involve most of the shaft. In all of the cases the line of diminished density followed a fairly characteristic pattern, being somewhat V-shaped near the posterior cortex. The line was broader than a simple, incomplete fracture. It did not extend through the entire shaft, and the amount of subperiosteal new bone was greater than is usually seen in an incomplete fracture. All lesions healed without any abnormality of the bone.

In 3 cases an exploratory operation and biopsy were done. Two of them showed fibrosis and cellular infiltration typical of chronic inflammation. The third case showed similar changes, but less marked, so that a definite diagnosis of chronic inflammation could not be made. All cases showed areas of typical bone regeneration and repair.

The authors believe acute trauma is not an etiological factor. The exact nature of the disease is not known. March foot is another condition which gives a similar roentgen appearance. There is a possibility that it may be an infectious process. Several German writers note its occurrence in other bones besides the tibia. Reischauer calls the lesion "wear and tear" fracture. Roberts and Vogt hope that study of the circulation in growing children may give some clue, as the pseudofracture line may be influenced by the course of a nutrient artery.

All the patients improved under rest and eventually became symptom-free. In one case, the condition recurred five months after the original onset, but this yielded to the conservative treatment used in the first attack.—*R. S. Bromer.*

Rothberg, Abraham S. Fractures of the carpal navicular; importance of special roentgenography. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 1020–1022.

Rothberg states that more emphasis should be placed on the clinical signs and symptoms in the diagnosis and treatment of fractures of the carpal navicular than on the roentgenographic findings. A negative initial roentgenographic examination does not necessarily rule out a fracture. Several variations from the usual technique have been employed when the posteroanterior view is negative for, or suspicious of, a fracture of this bone. Exposures should be made with the hand in ulnar deviation. Roentgenograms should be taken with the tube shifted a little to the right, and with it also shifted to the left. If, despite negative roentgenograms, clinical signs and symptoms exist, the part should be immobilized adequately. Sometimes, several weeks or months later, subsequent roentgenographic examination may reveal the fracture site which was brought to light by the process of osteoporosis.—*R. S. Bromer.*

Wörner, Eduard. Zur Frage der Abrissfraktur des Processus mastoideus. (Avulsion fracture of the mastoid process.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, October, 1939, *60*, 273–280.

Fractures involving the mastoid process of

the temporal bone are the result of great violence and are accompanied by serious cerebral concussion. Injuries producing avulsion of the mastoid process are very rare. A complete avulsion was described by Boullet (1878) before the beginning of the roentgen era. Such a case has not previously been reported in the roentgen literature. The patient was twenty years old, and riding a bicycle with one hand grasping the side of a truck when the side of the truck gave way and fell on to the right side of the patient's head throwing him to the ground. There was immediately profuse bleeding from the right side of his head. A skin laceration extended from the corner of the eye to behind the ear exposing the zygoma and the parotid gland. The ear itself was almost torn away. Lacerations were demonstrable in the external auditory canal and in the sigmoid sinus. The avulsion of the mastoid process was best shown in a postero-anterior film and the displacement was in a caudal, outward and posterior direction. Further information could also be obtained from direct lateral and tangential views, the latter being carried out according to Stenvers' technique.—*W. A. Evans, Jr.*

FERCIOT, C. FRED. A simplified directional guide for hip nailing. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 1023–1026.

Before introducing a flanged nail for internal fixation of a fracture of the femoral neck, it is necessary to determine three facts: (1) the point of insertion of the pin; (2) the angle of insertion in both anteroposterior and lateral planes; and (3) the length of the nail. Ferciot has employed a simple method of determining these findings and believes its use has greatly facilitated the operative procedure. The directional guide consists of a range finder and pin. It is described in detail and the illustrations show clearly the manner in which it is used.

By this method he has been able to determine accurately the length of the nail to be used and to direct fixation. The simplified roentgenographic technique which is also described shortens operative time, thus lessening shock to the patient.—*R. S. Bromer.*

MÜLLER, WALTHER, and LOEPP, W. Die Natur der umschriebenen Schenkelhalsaufhellungen bei der Perthesschen Krankheit. (The nature of circumscribed areas of rarefaction in the neck of the femur in Perthes' disease.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, October, 1939, *60*, 294–300.

In spite of much investigation, the basis for the changes occurring in Perthes' disease remains unknown. Mechanical, inflammatory, embolic, congenital, metabolic and endocrine factors have been put forward without much success or general acceptance. Attention has also been directed to the clear areas in the femoral neck which sometimes have almost the picture of Brodie's abscess, though they are not always present in Perthes' disease. A review of the material from the orthopedic clinic in Königsberg shows that these changes occur in the relatively young patients when the disease has begun before the fifth year. Recent studies have shown that the disease may begin as early as the third or fourth year. The changes in the femoral neck occur in a particular stage of the epiphyseal disturbance. They do not occur in the earliest stages of the disease and cannot be considered a primary change. The areas may also disappear before the process heals in the femoral head. The authors' observations indicate that they are of a purely secondary and transient nature. Comparison is made with similar changes which occur in the spine and calcaneus and which are sometimes misinterpreted as being inflammatory in character.—*W. A. Evans, Jr.*

CAVE, EDWIN FRENCH. Kienböck's disease of the lunate. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 858–866.

The term "Kienböck's disease" indicates a condition in which the lunate undergoes a slow, progressive, but incomplete degeneration with absorption of necrotic bone lamellae, followed by a fibrous tissue replacement. The condition is not common. Less than 100 cases have been recorded in the literature. It is probable, however, that often the diagnosis is not made because the symptoms are frequently not severe, and, unless roentgenograms are taken the disease will not be recognized. The cause is very probably trauma and not infection.

Cave reports 5 cases. Müller recognized three types of the disease: (1) the anatomical, due to abnormal pressure lines from anatomical anomalies; (2) the occupational, due to repeated minimal traumata; and (3) the traumatic, due to a single severe injury, that is, acute fracture of the bone. It appears, however, according to Cave, that there is no question that the essen-

tial cause is interruption of the blood supply with secondary necrosis, whether it be a crushing of the bone or a subluxation resulting in interruption of blood supply through the ligaments.

Roentgenographic changes may occur within a few weeks if the trauma is severe. If, however, it is slight, it is probable that months or years may elapse before changes are visible in the roentgenogram. The changes are usually more marked at the proximal portion of the bone. In the anteroposterior view early cyst formation and irregularity of the radial surface, with localized areas poor in calcium and others with a marked increase in calcium content may sometimes be seen. As the disease progresses, the bone becomes denser, smaller and more irregular in outline, taking on the appearance of a sequestrum. Usually it remains in this state, a dead bone. In certain patients the destroyed portion of the bone becomes fragmented. In the lateral roentgenogram, the density of the bone is increased, and the proximodistal diameter of the bone is lessened whereas the anteroposterior diameter is increased.

If the diagnosis is made early, before sequestration of the bone has occurred, the prolonged immobilization of the wrist may effect restoration of the blood supply and promote healing. If, however, the condition is of months' or years' standing, and if disintegration of the bone has occurred, careful excision of the entire lunate should be done.—*R. S. Bromer.*

Christophe, Kenneth. A functioning false shoulder joint following an old dislocation. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 916–917.

Christophe reports an unusual and interesting specimen which was uncovered in the anatomical laboratory in cleaning a shoulder girdle. A subcoracoid dislocation was found with fracture of the anterior rim of the glenoid. A hard, eburnated surface was present on the under side of the coracoid process, which was continuous with a like area on the new-bone formation that had taken place on the anterior surface of the neck of the scapula, after the injury. This corresponded to similar areas on the posterior border of the head and the greater tuberosity of the humerus. From the evident bone reaction, the joint capsule had been torn along nearly its entire attachment to the humerus, but with no disturbance about the glenoid except where the fracture of the rim took place. The attachment of the supraspinatus tendon was encroached upon, and there was evidence to show that the tendon assumed a new course, wearing a groove in the subcoracoid region. Likewise, the infraspinatus tendon smoothed over an area on the posterior rim of the glenoid to reach its attachment to the humerus. The long head of the biceps had apparently been ruptured, as the bicipital groove was nearly obliterated, except at the distal end, where a definite hole was found. This had evidently been made by callus surrounding the biceps tendon as it passed into the groove.—*R. S. Bromer.*

Gradoyevitch, Borivoye. Coracoclavicular joint. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 918–920.

The author reports a case of the bilateral occurrence of a joint between the clavicle and the coracoid process of the scapula. Previously 10 cases were reported in which the anomaly was proven anatomically and 5 cases in which the diagnosis was made by roentgen examination. In his case the large apophysis on the clavicle with a shape and a surface so exactly adapted to the surface of the coracoid process, led him to presume the existence of an articular capsule, synovial membrane, and cartilaginous surfaces. In Schlyvitch's case there was no such well-developed boss of bone, but nevertheless all of the elements of a joint were found. He did not feel justified in submitting his patient to the pain of experimental injection of contrasting substances such as uroselectan B or air, with the object of proving the existence of a joint cavity.—*R. S. Bromer.*

Simon, Harold E., and Williamson, Bryn. Epiphysitis of the os calcis. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 1015–1019.

Two cases of epiphysitis of the os calcis are reported. In children, especially in boys, between the ages of seven and one-half and seventeen years, the occurrence of painful heels should suggest the possibility of epiphysitis of the os calcis. The roentgenographic findings are characteristic, fragmentation, rarefaction narrowing and irregularity in outline of the epiphysis, with later excessive calcification. The condition is self-limiting, and recovery occurs spontaneously when the epiphyses unite at about the age of seventeen years. The etiology has not been definitely established, but the rôle

of trauma seems to be of some significance.—*R. S. Bromer.*

GARDEN, ROBERT S. Ossification in the anterior cruciate ligament. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 1027.

Garden reports a case of heterotopic bone formation in the anterior cruciate ligament. The patient was a bank clerk, aged eighteen years who had injured his left knee fourteen weeks before examination during a rugby match. Since that time the knee had shown a progressive instability, and the patient had ultimately been unable to rely on it even for ordinary walking.

Roentgenographic examination revealed a curious fenestrated appearance, as though the tibial spines had been bridged across by an abnormal bone shadow. In the lateral view, this shadow was situated in the center of the joint. The femur, patella and the tibia were normal. It seemed probable that the original injury involved the anterior cruciate ligament, resulting in localized hemorrhage with subsequent ossification therein.—*R. S. Bromer.*

BUSINCO, OTTAVIO. Complicanze osteo-articolari nel decorso della infezione maltese. (Bone and joint complications in Malta fever.) *Radiol. med.*, March, 1939, *26*, 258–264.

The literature shows frequent atypical localizations of the specific agent in Malta fever. Lesions in the endocardium, nerves and glands have been reported recently. Lesions of the bones and joints are somewhat more frequent. Spondylitis is relatively frequent and quite serious. The author describes 5 cases of osteo-articular complications with illustrative roentgenograms. Of these, 2 were in the coxofemoral joint, 1 in the lumbar spinal column, 1 in the elbow and 1 in the knee.

These cases differ from those of tuberculous osteo-arthritis in that there is new production as well as destruction of bone. The picture is very similar to that of osteo-arthritis from typhoid infection.

The prognosis is very favorable. The duration of the process depends on the severity of the lesion and the size of the joint involved. There is generally complete restoration to normal. The author had good results with intravenous vaccine treatment. As the results depend to a great extent on early treatment it is important to make a roentgen examination as soon as there are any signs of joint involvement.—*Audrey G. Morgan.*

ANDREESEN, REMMER. Ermüdungserscheinungen (Nekrose und Pseudarthrose) des Kahnbeins durch chronisches Trauma (Pressluftwerkzeugarbeiten). (Fatigue manifestations (necrosis and pseudarthrosis) of the scaphoid bone from chronic trauma (compressed air machine work).) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, October, 1939, *60*, 253–263.

Rostock has described changes at the elbow in workers using compressed air hammers which are occupational in character although they are occasionally seen in others engaged in heavy manual labor. Nevertheless the very important rôle of the constitutional predisposition to the occupational disease must be considered. Wette in 1930 was the first to associate necrotic change in the semilunar bone with compressed air hammer work. About two years of such employment are usually necessary for the manifestations to appear although one year may suffice.

In contrast to lunate necroses, which usually do not occur following a single trauma, partial necrosis and pseudarthrosis in the scaphoid bone is observed comparatively frequently following true fractures. This is in part due to the frequency with which fractures of the scaphoid bone are neglected or overlooked. However, pseudarthrosis between fragments of the scaphoid bone is sometimes seen as an incidental finding with no history of acute or chronic trauma. Such findings may be due to a congenital anomaly such as a bipartite bone and are not rarely bilateral. Irritative changes in the nature of an arthronosis deformans may then occur between the fragments as the result of occupational trauma. A fracture with post-traumatic cystic changes is often misinterpreted as a spontaneous fracture through an area of cystic bone structure, and this may be an important point difficult to decide in compensation cases.

In the year 1938, the author examined 74 hand injuries in workers using pneumatic hammers. There were 31 instances of lunate necrosis (5 bilateral) and 5 instances of pseudarthrosis (3 bilateral) in the scaphoid bone. Cysts of the carpal bones were seen in 18, and in 20 there were other findings. The insidious fracture of the scaphoid bone is comparable to the "march fracture" of the metatarsal bones. The end-result in such fractures may closely resemble that

following an imperfectly handled true fracture. In the author's 8 cases the ages of the patients were from twenty-six to fifty-three and the duration of work with the pneumatic hammer from 44 to 192 months. The fact, that some of the workers showed bilateral changes does not disprove their traumatic character for it is customary to alternate hands in using the hammers.—*W. A. Evans, Jr.*

ROENTGEN AND RADIUM THERAPY

HINTZE, ARTHUR. Bestrahlungserfolge beim Krebs aus 25 Jahren. 1180 Fünfjahrige—1004 Symptomfreie. (Radiation results in carcinoma in the course of twenty-five years.) *Strahlentherapie*, 1939, *66*, 189–202.

Between 1912 and 1933, 5,088 patients with malignant tumors were treated either by surgery or irradiation or both in the Surgical University Clinic of Berlin. The tumors were situated in the region of the esophagus, stomach, large intestine and rectum; some tumors were also found in the region of the brain and urogenital system. Of the 5,088 patients treated, 1,891 were treated surgically while 3,197 were irradiated or treated surgically and irradiated. In most of the cases roentgen radiation was given. In a few cases radium was used and in a limited number of cases radium and roentgen rays were used. Of all the irradiated cases 596 suffered from carcinoma of the skin, 919 from mammary carcinoma, 973 from carcinoma of the various regions of the mucosa and 709 from sarcoma; 1,075 cases were observed in the course of a five year period.

Of the 5,088 original cases, 36 per cent were still alive after five years. Of these 1,737 cases remaining alive after five years, only 557 were treated surgically exclusively, while 1,180 were treated either by roentgen rays alone or by roentgen rays and surgery. At the beginning of treatment, therefore, twice as many cases were operated on as irradiated, while at the end of five years, twice as many of the irradiated cases as of the operated cases remained alive. On the basis of these data, it is quite clear that at the end of five years infinitely better results are obtained in the cases which were irradiated than in the cases which were treated exclusively by surgery.

Of the 3,197 irradiated cases 1,180, or 37 per cent, remained alive after five years and 736, or 23 per cent, were free of symptoms after five years. Best results were obtained in cases of skin carcinoma. Of these after five years 65 per cent remained alive and 48 per cent of these were free of symptoms. Of the cases of mammary carcinoma, 36 per cent remained alive after five years and of these 20 per cent were free of symptoms. Of the cases of sarcoma, 38 per cent remained alive after five years and of these 26 per cent were free of symptoms. The poorest results were obtained in cases of carcinoma of the mucosa. Here after five years 19 remained alive and only 9 per cent of these were free of symptoms.—*A. Schwartzman.*

GUTHMANN, H., and DÖRR, H. Die Behandlungsergebnisse unserer Karzinomfälle vom 1. Januar 1927 bis 31. Dezember 1931. (Results of treatment of carcinoma cases obtained between January 1, 1927 and December 31, 1931.) *Strahlentherapie*, 1939, *66*, 440–447.

The present report deals with cases of carcinoma each of which was verified by histological examination. Only those cases were considered as cured which appeared completely free of recurrence after five years of observation. All cases of carcinoma were classified into Group 1—definitely operable; Group 2—borderline cases and Group 3—definitely inoperable. Carcinomata of the cervix were classified into carcinoma of the portio and cervical carcinoma.

Of the 56 cases of Group 1, 27 were operated on and then subjected to roentgen therapy. Of these, 8 were cured giving, therefore, a percentage of 29.6. Twenty-nine cases of this group were only irradiated. Of these 9 were cured, giving a percentage of 31.03. These figures clearly show that there is no essential difference between the results obtained from irradiation alone and surgery and irradiation.

Thirty-five cases belonged to the borderline group, that is to Group 2. All these cases were treated with radium and roentgen rays. Seven of these were cured giving, therefore, a 20 per cent cure. Group 3 was represented by 156 cases. Most of these were treated surgically combined with radium and roentgen rays and a cure was obtained in 15, that is in 9.6 per cent.

Of the 70 cases of carcinoma of the cervix, 20 were cured, or 28.5 per cent. Thirty-three of these patients were operated on and then subjected to radium and roentgen treatment. In these cases 11, or 33.3 per cent, were cured. Thirty-seven of the cases were treated with roentgen rays and radium alone and in these a

cure was obtained in 24.4 per cent. In Group 2 of this series of cases, a cure was obtained in 23.8 per cent. None of these cases was surgically treated. In Group 3 a cure was obtained in 11.4 per cent.

Sixteen cases of primary vaginal carcinoma were treated. In 11 other cases it could not be determined with certainty whether the carcinoma originated secondarily from the cervix. Not one of these 11 cases was cured. Only one of these cases lived four years and four months while the remaining 10 cases died in less than three years after treatment. All the 16 cases of clear cut carcinoma of the vagina were treated surgically and by irradiation. Only one of these, a woman fifty-two years of age, was cured and was found free of symptoms after a period of ten years. Four cases of carcinoma of the vulva were treated and none were cured. Of the 24 cases of definite carcinoma of the ovaries, 5, or 20.8 per cent, were cured.—*A. Schwartzman.*

GAINI, GIUSEPPE. La curieterapia degli epiteliomi gengivali. (Radium therapy of epitheliomata of the gums.) *Radiol. med.*, Jan., 1939, *26*, 32–41.

The author discusses 53 cases of epithelioma of the gums treated at the Radiological Institute of Milan. Epitheliomata of the gums are relatively rare. There are two methods of treating primary tumors of this kind—by the introduction of radium needles into the tumor and by the use of paste apparatus fitted to the site of the tumor and containing the radium needles. The advantages of the former method are that it is possible to give large doses and limit the action to the tumor, sparing the surrounding tissues. The charge of the needles is generally 1 to 2 mg. radium element; the dosage given in six to seven days varies from 1.5 to 2 millicuries-destroyed per cubic centimeter of tissue irradiated. The dangers of the method are that the tumor may be too small for the action of the radium to be limited to the tumor and there is more danger of necrosis from concentration of large doses near bone. For these reasons the technique with modeled apparatus is increasing in favor. The total time of treatment with this method is sixty to eighty hours, divided into daily sessions of six to eight hours; the dosage is not more than 2 millicuries-destroyed per cc. of tissue with apparatus covering a small surface and not more than 1.5 millicuries-destroyed for moderate or large areas.

Another method of treatment that has proved successful in some cases at the Institute is that of plesioroentgen therapy, that is roentgen treatment by the method of Chaoul with a short focal distance (5 cm.), on small fields, only a few square centimeters, with soft rays (50–60 kv., filter 0.2 mm. copper). This treatment is possible, however, only for small tumors located on the labial side of the gums which are readily accessible.

If the tumor is found amenable to radium treatment and the glands are involved the irradiation should be preceded by radical surgical removal of the glands, including the deep glands involvement of which would not be suspected on clinical examination. If the glands are not involved radiotherapy is given with the purpose of bringing about sclerosis of the lymphatic tracts and thus preventing dissemination of the tumor. If the tumor has advanced so far as to be inoperable, only radiotherapy is used.

Statistical tables are presented which illustrate various problems of the treatment. Among the 53 cases examined at the end of six months, 16 (30.2 per cent) were well, 21 dead and 16 lost sight of; among the 35 cases examined at the end of three years, 9 (25.7 per cent) were well, 18 dead and 9 lost sight of, among the 21 examined at the end of five years, 6 (28.5 per cent) were well, 9 dead and 6 lost sight of. These figures show that the cases once healed tend to remain so. The greater part of the mortality occurs in the first year of treatment.

Statistics show that the lower jaw is more frequently affected than the upper, 68 per cent as compared with 32 per cent; the best results are obtained in tumors of the upper jaw; an immediate cure of 47 per cent as compared with 22.2 per cent in the lower jaw. The best results are obtained in cases without metastasis. Better results were obtained in cases not previously treated than in those with recurrence after treatment; 20 per cent cure in the latter group as compared with 32.5 per cent in the former. The majority of recurrences occur within the first five months after treatment. Eleven cases were retreated after recurrence and in 2 of these cure persisted for seven years, showing that treatment is worth while even in extremely serious cases.—*Audrey G. Morgan.*

ANZILOTTI, ALBERTO. Un caso di leishmaniosi cutanea trattato con raggi x. (A case of skin leishmaniosis treated with roentgen rays.) *Radiol. med.*, March, 1939, *26*, 264–265.

A woman of thirty-three was sent to the author with leishmaniosis of the skin. She had a torpid ulceration with a sanious secretion on the anterior surface of the right arm just above the bend of the elbow. This had been developing slowly for two years on a papule which had been the first sign of the disease. Examination of a smear showed the causative agent.

The author decided to use Palmieri's method of plesioroentgen therapy. Treatment was begun May 5, 1938, with a limitator of the Palmieri type; 150 r (measured in air) was given daily for six days. Total dose 900 r; roentgen illumination r/m 8.32; focus-skin distance 23 cm. Height of the block of paraffin 7 cm., height of the air chamber between the paraffin and the skin 5 cm.

In the week following the irradiation there was quite an intense reaction with great redness of the skin around the ulcer. When the patient was seen forty days later there was perfect healing with a smooth scar. The author recommends this method of treatment in similar cases.—*Audrey G. Morgan.*

Bode, H. G., and Kliegel, Hubert. Richtlinien für die Anwendung der Nahbestrahlung bei Epitheliomen der Haut. (Guiding principles for the use of close irradiation in epithelioma of the skin.) *Strahlentherapie*, 1939, *66*, 96–107.

1. The indications for close irradiation are limited to primary tumors. Only in rare exceptional cases (advanced carcinoma of the penis and of the extremities) occasionally a radical surgical procedure is to be considered.

2. Isolated glandular metastases up to about the size of a pea are best irradiated from a focal skin distance of 10 cm. A severe erosive reaction must be guarded against. This irradiation usually leaves a smooth, non-pigmented atrophy.

3. In carcinoma of the lower lip besides the excessively close irradiation of the primary tumor a surgical removal of the present metastases followed by a short distance irradiation is recommended. If no glands are palpable the glandular region must be examined for three months at two to three weekly intervals and at longer intervals later. If metastases appear the procedure presented above should be followed.

4. The single irradiation is indicated only in basal cell epithelioma. It is applicable to about 50 per cent of the cases and is limited to flat forms not exceeding 2 cm. in diameter which are not fused with the bony tissue. A dose of 2,000 r is to be used. If necessary, the irradiation is to be repeated after the reaction has subsided. If the dose is decreased recurrences may be expected.

5. A 5 cm. to 3 cm. focal skin distance should be employed only in cases of senile keratoma and in erythroplasia. Also here a single dose of at least 1,500 r should be used.

6. In fractional irradiation the largest possible effect should be obtained during the first series. This should be followed by further irradiations until the errosive reaction is obtained. A premature discontinuance of the series of treatments leads as a rule to recurrences. Of significance is only the reaction of the neighboring tissues. In basal cell epithelioma situated on the bony tissue larger doses must be employed. In carcinoma of the lower lip an erosive reaction of the mucosa may appear prematurely which must not serve as a reason for discontinuance of the irradiation.

7. Lupus carcinoma, because of its great radiosensitiveness begins to regress shortly after the treatment is instituted. Even here, however, the treatment should be continued until an erosive reaction has been obtained in order to prevent recurrences.

8. Cases previously intensively treated with radium and roentgen rays must preferably and basically be treated by the fractional method. In most cases more than one series of treatments is necessary.

9. The minimal dose in fractional treatment is 4,000 to 5,000 r in ulcus trebrans and spinocellular forms, gradually increasing up to 10,000 r or more.

10. Epithelioma appears in relatively young individuals, frequently requiring a relatively high dose. Cases of this type should preferably be treated by the fractional method.

11. Radiation therapy of epithelioma should be given only by physicians thoroughly skilled in this method of treatment.—*A. Schwartzman.*

Pfeifer, Walter. Zur Behandlung der Drüsenmetastasen bei Zungenkarzinom. (Treatment of glandular metastases in carcinoma of the tongue.) *Strahlentherapie*, 1939, *66*, 468.

A comparison of the world statistics dealing with the results obtained from surgical and radiation treatment of glandular metastases of carcinoma of the tongue reveals that the midway or the combined radiation-surgical treat-

ment of carcinoma of the tongue is the proper way. The surgical statistics of König and Seifert gave an average cure, that is free of recurrences after three years, of 17 per cent. The surgical mortality in these cases varied from 10 to 15 per cent. A similar study of statistics dealing with the combined radiation-surgical treatment reveals a eure of 25 per cent and a considerably smaller surgical mortality. On the basis of these data one is justified in stating that the combined radiation-surgical treatment gives best results. The prognosis of carcinoma of the tongue is based entirely on the glandular metastases. It is not surprising, therefore, that numerous attempts have been made to find a method which would prevent these metastases. A thorough study of the literature dealing with the subject reveals that the surgical removal of existing glandular metastases even when they are very small and not very extensive and when the surgical removal is most thorough does not give satisfactory results in a predominant number of cases. A very rapid recurrence in the surgical scars, at times after four to six weeks, and a very rapid growth of these recurrences is the rule.—*A. Schwartzman.*

SCHINZ, HANS R. Der Stimmbandkrebs. (Carcinoma of the vocal cords.) *Strahlentherapie*, 1939, *66*, 203–218.

Laryngeal carcinoma is classified into carcinoma of the internal and of the external larynx; this classification is of considerable significance from the prognostic as well as from the therapeutic viewpoint. The designation external laryngeal tumors is limited to tumors which originate from the upper margin of the larynx, namely, from the epiglottis, from the pharyngoepiglottic plica, from the aryepiglottic fold and from the arytenoid region. Some clinicians include also the posterior cricoid carcinoma in the external laryngeal carcinoma. As a rule also carcinoma of the pyriform recess is included in the external laryngeal tumors. This author classifies the hypopharynx carcinoma in three groups. (1) malignant tumors of the upper circumference of the larynx; (2) malignant tumors of the pyriform recess, and (3) the remaining hypopharynx tumors. From the above one must differentiate the inner laryngeal tumors. These are characterized especially by a slow growth and late metastases simulating, therefore, in a certain respect, tumors of the external skin. In a predominant number of cases, these originate from the genuine vocal cords and consequently they are frequently spoken of as vocal cord carcinoma. However, they may take their origin from any other place in the inner larynx, namely, from the inner surface of the epiglottis, from the inner laryngeal wall, from the false vocal cords, from the sinus of Morgagni or they may be situated subglottically or hypoglottically. Of all these the most important is the genuine carcinoma of the vocal cords although quite frequently one finds malignant tumors of the false vocal cords and subglottic malignant tumors.

In cases of carcinoma of the vocal cords one usually obtains a history of hoarseness lasting for months or years; in some instances the degree of hoarseness increases rather rapidly and there appear respiratory disturbances and at times even disturbances in deglutition. The classical early symptom suggestive of laryngeal carcinoma is hoarseness of long duration in individuals of over forty years of age. The hoarseness is frequently combined with attacks of coughing and at times with pain radiating towards the ear. In cases of subglottic carcinoma, on the other hand, symptoms of dyspnea and stridor appear relatively early. Laryngeal pain and disturbances in deglutition are practically invariably present in advanced stages and point to a perichondritis or perforation into the hypopharynx. Finally dyspnea and laryngeal edema appear and death occurs as a result of suffocation or as a result of aspiration carcinoma following ulceration of the tumor. Metastases into the lymph nodes appear relatively late. According to the author's experience, the infiltration of the prelaryngeal lymph nodes is very rare. Histologically one deals in vocal cord carcinoma in the predominant number of cases with a pavement cell carcinoma of the skin type. Other histological types, however, may be present and occasionally even a sarcoma may be found. The diagnosis is relatively easy and may be somewhat difficult only during the early stages of the disease. Any anatomical change in the vocal cord which is unilateral, observed in patients over forty years of age, should be suspected of carcinoma. The condition must be differentiated from tuberculosis, tertiary lues, papilloma, polyps and pachydermia. It must also be differentiated from amyloid tumors. A diagnostic excision which is usually harmless verifies the diagnosis.

The roentgen treatment of inner laryngeal carcinoma has been carried out only during the

last ten years. The surgical results obtained in cases of this type are very satisfactory. The good surgical results, however, are associated with considerable degree of crippling while roentgen treatment eliminates the crippling. This would suggest that in some cases even where surgically good results could be expected, roentgen treatment may be indicated.

Between 1929 and 1937 the author treated by the protracted fractional method 39 cases of carcinoma of the vocal cords. One year after the treatment 17 of the 39 cases were free of symptoms, or 43 per cent; after three years 27 per cent of the cases treated were alive and free of symptoms and after five years 25 per cent were free of symptoms. In comparison with the surgical results, these results are not very satisfactory. It must be remembered, however, that nearly all of these cases were referred to the author and consequently the disease was as a rule in an advanced stage.

The author is of the opinion that protracted fractional roentgen irradiation is the method of choice in the treatment of carcinoma of the vocal cords. He believes it is preferable to surgical therapy because it minimizes the danger to the life of the patient and because it gives better functional results.—*A. Schwartzman.*

Körbler, Juraj. Zur Radiumtherapie des Ösophaguskarzinoms. (Radium therapy in carcinoma of the esophagus.) *Strahlentherapie*, 1939, *66*, 219–223.

According to Seifert, surgical removal of the esophagus in the cervical region is one of the most dangerous operations because the surgical mortality is about 33 per cent. Besides, the prospects of a cure are not always very favorable. The results are even poorer regarding the thoracic segment of the esophagus. The results of radiation treatment of carcinoma of the esophagus are similarly not very encouraging. In a predominant number of these cases only palliative treatment can be employed. Quite frequently, however, even by the aid of palliative treatment alone it is possible to maintain the patency of the esophagus and the patient may be spared numerous unpleasant symptoms.

According to Schinz the method of choice in the treatment of carcinoma of the esophagus is protracted fractional roentgen irradiation while the intracavity radium treatment should be considered only as an accessory aid.

Between 1931 and 1935, the author had an opportunity to study and treat 42 cases suffering from carcinoma of the esophagus. In 7 of these cases the cardiac portion of the esophagus was affected while in the remainder the thoracic portion was involved. The author does not discuss here the cases where the cervical portion of the esophagus was affected. Of the cases where the cardiac portion of the esophagus was involved, 4 were males and 2 females. In 4 patients the treatment was carried out by means of radium where a moulage was introduced into the cardiac region while in 2 a permanent sound was introduced with radium into the regions of stenosis. In neither of these cases could a considerable prolongation of life be obtained. The average duration of life from the beginning of the disease up to death in these cases was 9.5 months. In each of these cases, however, it was possible to maintain the patency of the esophagus and to eliminate most of the unpleasant symptoms.

Of the 35 cases where the thoracic portion of the esophagus was involved, 31 were males and 4 females. The average age of the males was 56.6 years while the 4 women were 27, 50, 65 and 67 years of age respectively. Thirty-two of these patients were observed up to the end. Two of the patients were admitted in a moribund stage and died shortly after admission. In one of these the disease was of five and in the other of nine months' duration. One patient was treated only with roentgen rays. The patient died five months after treatment. In this case the duration of the disease was thirteen months. In 7 patients the combined roentgen-radium treatment was employed. The average duration of the disease in these patients was twelve months. In 2 of these the clinical symptoms were so much improved that the patients were able to swallow without difficulty.

Even though the results obtained in these cases in regard to life were not satisfactory, nevertheless in practically all the cases treated it was possible to maintain the patency of the esophagus up to the end and thereby to render the life of the patients considerably more pleasant.—*A. Schwartzman.*

Schittenhelm, A. Aus dem Indikationsgebiet der Strahlenbehandlung von Hypophyse, Schilddrüse und Nebenniere. (The main indication for radiation treatment of the hypophysis, thyroid and suprarenals.) *Strahlentherapie*, 1939, *66*, 373–427.

In 1906 Gilmer revealed for the first time his results obtained from personal experience of a study of a number of cases where roentgen treatment was employed in the management of goiter. Of the 23 cases studied, the colloidal cystic and fibrous forms showed after the treatment a regression corresponding to the degree of existing parenchymatous tissue; best results were obtained in cases of parenchymatous goiters. Under the influence of the treatment the clinical symptoms decreased, although in some instances aggravations were observed. In 7 cases of Basedow's disease, this author obtained a prompt reaction in the form of a rapid gain in weight, a decrease of the nervous symptoms, a slowing of the pulse and a subjective improvement. Gilmer recommended, therefore, roentgen therapy in all benign and severe cases. More or less similar results were reported in 1915 by Kienböck.

Somewhat later roentgen therapy was employed also in the treatment of the hypophysis. In 1925, Politzer came to the conclusion, on the basis of his observations, that Basedow's disease is not a disease *sui generis*, but is only a syndrome, a complex of disturbances of various nerve centers which may be originated not only from the thyroid gland, but also from other endocrine glands. He came to the conclusion that there exists not only a psychogenic or a genital but also a hypophyseal form of Basedow's disease. In the latter the following characteristics are present: No changes in the thyroid gland, severe tremor reaching a degree of ataxia, definite changes in the specific dynamic action of proteins which manifest themselves in an increase of the basal metabolic rate and no response to iodine medication. On the basis of these conclusions it was logical to subject the hypophysis to roentgen treatment. This served as a basis for roentgen therapy of the hypophysis. Presumably in many instances roentgen irradiation of the hypophysis gave satisfactory results.

The author collected a number of cases from the literature on the basis of which he believes to be justified in stating that roentgen therapy is definitely indicated in many cases of thyroid disease. He is of the opinion that even in very severe cases, roentgen therapy in combination with internal medication has a life saving effect, especially in the cases where any other form of therapy remained ineffective. The roentgen treatment may eliminate the thyreotoxic crisis and may render an inoperable case operable. It cannot be denied, however, that in many cases of Basedow's disease with severe symptoms, roentgen treatment may produce an unfavorable result. Special care must be exercised in cases complicated by an involvement of the liver, pancreas, and heart. In cases of thyreotoxicosis treated by roentgen therapy, the results of treatment should be based on the behavior of the basal metabolic rate and of the blood iodine content. The latter, especially in favorably influenced cases, reacts more promptly than the basal metabolism.

The favorable effect from roentgen irradiation of the thyroid gland is the result of a decrease of the thyreotropic hormone in the thyroid gland. This also explains the favorable results obtained in cases of this type from roentgen irradiation of the hypophysis since it is known that a thyreotropic hormone is secreted in and excreted from the anterior lobe of the hypophysis.—*A. Schwartzman.*

BIANCHINI, A. Come curare oggi il morbo di Flajani-Basedow? (How should Flajani-Basedow's disease be treated at the present time?) *Radiol. med.*, Feb., 1939, *26*, 130–144.

The author discusses the different types of Basedow's disease and reviews the chief methods of treating them: (1) the dietetic and medicinal; (2) the surgical, and (3) the radiotherapeutic. Mild cases can be treated with diet and iodine but the severer cases require surgery or roentgen rays. Many surgeons advocate surgery only but the author is convinced that roentgen treatment is to be preferred. The results are better and it is so free of danger that it should be preferred even if the results were equal.

Bianchini uses a fractional method of irradiation following a careful roentgenoscopic and roentgenographic examination of the chest and a study of heart function and basal metabolism. He uses a tension of 135 to 140 kv. and a filter of 0.5 mm. zinc or copper and 3 mm. aluminum with a focal distance of 30 cm. He uses three fields 6×8 cm., one on each lobe and one over the isthmus. If the thymus is persistent he extends the irradiation to cover it and if other endocrine glands are involved they are irradiated also. He has never used electrotherapy or radium therapy in association with the treatment. He gives not more than 10 per cent skin erythema dose for the first dose for each field. As a rule he gives 3 series of irradiations of four to six

applications each on alternate days with a total dose to each field and series of 320 to 480 r. If further treatment is necessary he increases the number of series rather than the size of the individual doses or the number to a series. He bases his conclusions as to the success of treatment on the general condition of the patient—pulse, weight and basal metabolism rather than on the size of the goiter and the exophthalmus.

He reports 71 cases treated, with a table showing details of technique and results. He had cure in 33, great improvement in 17, improvement in 13 and no improvement in 8; that is, there was cure or improvement in 88 per cent of the cases. The poorest results were in 1925 to 1933 when the technique had not been perfected. Since then he has had excellent results. Many of the patients seen after one to four years showed persistence of the good results. There were no harmful by-effects in any of the cases. The results were better the younger the patients and the more recent the disease.—*Audrey G. Morgan.*

Gauss, C. J. Die Unfruchtbarmachung durch Bestrahlung. (Sterilization by irradiation.) *Strahlentherapie*, 1939, *66*, 545–560.

In the entire material studied by the author only two pregnancies occurred, representing about 0.2 per cent of all the treated cases. Whether these pregnancies were already present at the time of irradiation or occurred later could not be determined. At any rate, by proper care they could be recognized or prevented. On the basis of the extensive studies of the author, he believes he is justified in drawing the following conclusions:

For purposes of sterilization for the prevention of hereditary diseases, besides operation, irradiation is available. Irradiation is indicated in individuals of a certain age, in the presence of conditions which contraindicate an operation which exist in some women but where irradiation can be carried out without any danger to the life of the patient; irradiation is especially indicated in women suffering from severe psychic diseases, especially because in women of this type postoperative care is very difficult and at times impossible, while no special care is necessary following irradiation since hospitalization for this purpose varies from one to three days where roentgen rays are used and from five to seven days where radium is used.

The results of irradiation are quite satisfactory. The menstrual effects of the irradiation disappear even under the usual technique of irradiation and this can be considerably improved with a refinement of the technique. A refinement of the technique will also prevent the frequency of failures. The after-effects of irradiation in the sense of roentgen burns are relatively slight and are never comparable with the after-effect of operations. The after-effects of the irradiation in the sense of menopause symptoms are not severe; there is practically no danger to the life of the patient following irradiation. The working ability of the patient is not demonstrably influenced by irradiation.

Roentgen irradiation is preferable to radium irradiation because it is infinitely less dangerous, it is not as painful and more pleasant to the patient and the duration of hospitalization is shorter. Radium irradiation, on the other hand has the following advantages: the monopause symptoms are considerably less severe and amenorrhea appears in many cases more rapidly.—*A. Schwartzman.*

Gal,. Felix. Gebarmutterkrebs und Ovarialfunktion. (Uterine carcinoma and ovarian function.) *Strahlentherapie*, 1939, *66*, 570–582.

An attempt was made by the author to determine on his clinical carcinoma material the following questions:

1. Does there exist a relationship between the age of the carcinoma patient and the healing tendency of the tumor?

2. To what extent is the healing tendency of given cases influenced by the presence or absence of the ovarian activity?

3. What is the healing tendency of genital carcinoma in comparison with the healing tendency of tumors of other organs, and

4. What conclusions can be drawn from the results of the postoperative prophylactic irradiations?

The rôle of ovarian function in the development of carcinoma is shown by the age distribution of carcinoma. It is generally recognized as a disease of a higher age. If this is the case then the development of carcinoma could no longer be influenced by the internal secretion of the ovaries.

A study of the extensive statistics dealing with the subject shows, however, that uterine carcinoma may occur at any age. In the author's own material the youngest patient

suffering from uterine carcinoma was twenty-four and the oldest seventy-seven years of age. Most of the patients studied varied in age from thirty to sixty. It was found in general that the number of cases gradually increases up to the menopause, reaching its highest point at the time of menopause, and gradually decreases after that. The largest number of patients occurs in individuals of preclimateric age at a time when the inner secretory apparatus still functions regularly; even during the years of menopause and shortly afterward, at a time when the ovarian activity is gradually disappearing, the affection is quite common; from the above it would appear that the generalization that carcinoma is a disease of advanced age is not applicable to uterine carcinoma.

No definite statistical data are available in regard to the healing tendency of the tumors and the age of the patient. It is generally assumed that carcinoma of younger individuals metastasizes rapidly, is cured with difficulty and recurs rapidly after operation while carcinoma of older women is relatively more benign. This assumption is somewhat substantiated by clinical experience.

The author compared the results obtained from surgery in carcinoma patients with and without functioning ovaries. This study has shown that from the viewpoint of surgical cure the age of the patient is of great significance: in women below forty-five years of age an early recurrence of the tumors occurred twice as often as in women above forty-five years of age. It would appear, therefore, that in older women the protective powers towards a new formation of the tumors are considerably better developed. It would appear, therefore, that from the viewpoint of carcinoma healing the persistence of the ovarian function after operation is of significance and it would appear that the continuous function of the ovaries following operation has a definite influence on the further fate of the patient, namely, recurrences appear to be less common after operation in women where the ovaries are not functioning at all as compared with the women whose ovaries still continue to function.

The author's studies have also shown that postoperative prophylactic irradiation has a definite favorable effect on the results obtained in cases of uterine carcinoma. The mechanism of action of the postoperative irradiation, however, is still not clear. It has been contended by some authors that the improvement in the results obtained is due to the destruction of carcinoma tissue left in the pelvis; this contention, however, has never been definitely proved: this author is of the opinion that the improvement in results following postoperative prophylactic irradiation is more probably due to its effect on the ovaries. A comparison of the effectiveness of prophylactic radium and roentgen irradiation reveals that roentgen irradiation, at least in the author's clinic, is preferable to radium irradiation.—*A. Schwartzman.*

GAL, FELIX. Die Therapie der Scheidensarkome. (Therapy of sarcoma of the vagina.) *Strahlentherapie*, 1939, *66*, 224–229.

The present report is based on a study of 4 cases of sarcoma of the vagina. In all these cases combined radium-roentgen therapy was employed and satisfactory results were obtained. The good primary results, the complete disappearance of the tumor, are the more surprising because the results of treatment of genital sarcoma just as of sarcoma in general are as a rule not very satisfactory. Even after a radical excision, sarcoma recurs relatively or considerably sooner than carcinoma and leads to cachexia and death. Apparently at the very onset of the disease sarcoma produces a definite effect on the general condition of the patients which leads to a practical destruction of the resistance of the body, which explains the rapid recurrence.

Sarcoma of the vagina is, as a rule, quite extensive, diffuse, approachable with difficulty, its surface as a rule is covered with a serosanguineous layer and intact vaginal mucosa alternates with necrotic regions. Only in rare cases the tumor is circumscribed and appears cystic on palpation.

The tumor is easily differentiated from fibroma and myoma. Vaginal sarcoma is usually of the spindle or round cell type. From the therapeutic viewpoint it is important to know that the tumor as a rule does not extend to the bladder and urethra and practically never forms metastases, differing in this way from the same type of tumor in children. The tumor is observed in women of various ages. Biologically it resembles mostly, because of its rapid growth and its great radiosensitiveness, chorionepithelioma.

As mentioned above in the 4 cases treated by the author combined radium-roentgen therapy was employed; 60 mg. of radium was introduced

for twenty-four hours and twenty-four hours after the radium was removed, a roentgen treatment was given, the rays being concentrated on the region of the tumor. The treatment was repeated at intervals of five weeks and two or three treatments were usually employed. A pronounced and definite recurrence of the tumor was never observed after the first treatment. The author believes that this form of treatment is the method of choice and is preferable to surgical treatment. His statement is based on the fact that this type of tumor reacts better to radiation treatment than carcinoma; because of the anatomy of the region and localization of the tumor, surgery in these cases is practically hopeless. The 4 cases treated by the author have so far been observed in the course of two years during which time they remained free of symptoms.—*A. Schwartzman.*

Knierer, W. Zur Röntgennahbestrahlung der Induratio penis plastica. (Radiation treatment of plastic induration of the penis.) *Strahlentherapie*, 1939, *66*, 143–144.

This author had an opportunity to treat roentgenologically 6 cases of plastic induration of the penis. One of these cases appears to have remained cured following an observation period of ten months. Three of the patients appeared definitely improved subjectively and objectively but are still under treatment and observation. One patient remained uninfluenced by the treatment and in one the treatment has not been carried out for a sufficiently long period to permit conclusions.

The dose of roentgen rays employed varied. The patient which so far remained cured for ten months was treated at intervals of eight days with doses of 200 r, repeated twice. The patient where the condition remained uninfluenced, on the other hand, received altogether 1,400 r in the course of two months, one of the doses being 500 r and the remaining doses 300 r each. The 3 improved patients received a dosage of 1,700, 2,000 and 2,100 r respectively, at intervals of two months, two months, and five months respectively, the individual dose varying from 300 to 500 r. In order to obtain a sufficient deep effect the radiation was given in each case with a focal skin distance of 5 cm. In order to prevent an injury to the skin the foci were irradiated from various planes.—*A. Schwartzman.*

MISCELLANEOUS

Sloat, J. I., and Peterson, Leonard T. A new device for facilitating the taking of roentgenograms when performing the extra-articular method of internal fixation in fractures of the femoral neck. *J. Bone & Joint Surg.*, Oct., 1939, *21*, 1041–1044.

The authors employ a specially designed tunnel or film changer which can be screwed to the fracture table by means of a screw-bolt which bisects the holder and engages a threaded sleeve on the pelvic post of the fracture table. The under surface of the tunnel or holder rests upon the pelvic seat of the table. This device affords a means of obtaining satisfactory roentgenograms with no disturbance of the patient and with a minimum of effort during the operation. It is not only of value in exposure of the anteroposterior view, but it is decidedly helpful as a rest upon which to support the cassette in taking the lateral view. Another advantage is the fact that it furnishes a firm support upon which the patient rests during the reduction of the fracture and the subsequent operation. The tunnel is also used routinely in checking the fracture site for position and callus during the convalescent period. The tunnel may be entered from both sides so that it may be used for either hip.—*R. S. Bromer.*

Turano, Luigi. Ulteriore contributo alla plesioradiografia. (Recent contribution to plesioroentgenography.) *Radiol. med.*, Feb., 1939, *26*, 113–122.

The author discusses the method of plesioroentgenography in which the roentgen film is placed directly in contact with the part to be examined; the tube is placed in contact with the opposite part; the normal ray falls on the center of the film. The roentgenogram is taken with an exposure of 1/10 to 1/20 of a second with soft rays (15 to 30 or rarely 40 kv. according to the subject and the part to be examined) but with a very high intensity (300 to 500 ma.). The intensity may be decreased to 60 to 80 ma., increasing at the same time either the tension or the time, preferably the latter. With this method only the layer directly in contact with the film is in focus, and the ones further away are so blurred and indistinct that they are practically eliminated from the roentgenogram.

This is only one of the methods of stratigraphy, that is of roentgenographing only a single

layer of tissue, so that the author considered adopting the name of monostratigraphy for it. It is of little value in roentgenographing lung tissue for the superposition of many shadows of slight intensity which are indistinct and enlarged spoils the clearness of the roentgenogram. But it is of great value in examining bones and in identifying some lesions in the upper quadrants of the diaphragm such as renal and biliary calculi and calcifications.

A number of roentgenograms illustrating the use of the method are given. It should be used only in conjunction with ordinary roentgenography. The technique is easy and it is inexpensive, as films not larger than 18×24 or 13×18 are used. It is used for studying the minute details of small parts that have previously been roentgenographed by the usual methods.—*Audrey G. Morgan.*

CIGNOLINI, PIETRO. La regmografia. (Regmography.) *Radiol. med.*, Jan., 1939, *26*, 44–50.

In 1934 the author published a new roentgen technique which he calls regmography, from the Greek word "regma" meaning a fissure. It is designed for studying limited sectors of moving organs; complete images of the parts are obtained and not simply diagrams of their displacement as in kymography. The author developed the method particularly for obtaining a series of good images of the apices of the lungs during an attack of coughing, though it may be used for studying other organs, as for example the heart. He used his kymograph, placing the patient in front of it as in that method. But the whole wall was lined with lead, leaving only a fissure about 16 mm. wide. The roentgen film is made to glide rapidly past this fissure, at the rate of 10 to 20 cm. per second or even more. The part of the body to be studied is exposed in front of the fissure. Brief flashes of roentgen light are emitted rhythmically of a duration of about a thousandth of a second each. A definite proportion is maintained between the number of flashes and their duration, the length of the fissure and the rapidity of passage of the film.

Images of the apices of the lungs obtained by this method are given.—*Audrey G. Morgan.*

GILARDONI, ARTURO. Generatore di lampi di luce roentgen di 1/1000 di secondo per regmografia e seriografia. (A generator for flashes of roentgen light 1/1000 of a second in length for regmography and seriography.) *Radiol. med.*, Jan., 1939, *26*, 51–55.

In a previous article Cignolini has described the principles of regmography, which consist essentially of taking a series of roentgenograms on a moving film of a part of the body placed before a fissure in a lead wall. Both film and the part of the body are moving. The author described and illustrates an apparatus for producing the brief and rapid flashes of roentgen light (1/1000 of a second in duration) required for this method. The flashes are produced by the discharge of a condenser. The greater the degree to which the tube is heated, the more rapid the flashes of light. The diagrammatic illustration shows the relative position of the various parts of the apparatus.—*Audrey G. Morgan.*

JAMES T. CASE
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